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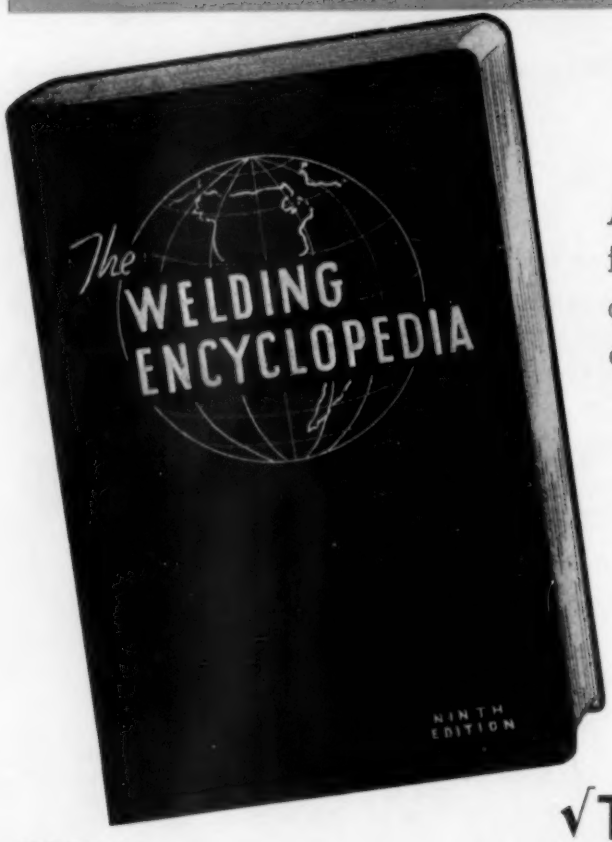

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Reader Cooperation

OUR RECENT SURVEY of reader interests and problems was planned for the purpose of working out an editorial schedule that would meet the needs and desires of the majority of our readers. Publishers, like manufacturers of industrial equipment or consumer goods, to be successful, must design and build their products to win customer acceptance. This is the basic idea underlying all market research work.

The response has been very gratifying, slightly more than 10% of the questionnaires mailed to our readers were returned to us properly filled out. While we do not presume to set ourselves up as experts on direct mail returns, we do feel that the readers of THE WELDING ENGINEER have cooperated with us to a most helpful degree. Tabulating these questionnaires and analyzing the data has kept us about as busy as election clerks in a polling place after the doors are closed and the tedious process of counting the votes gets under way.

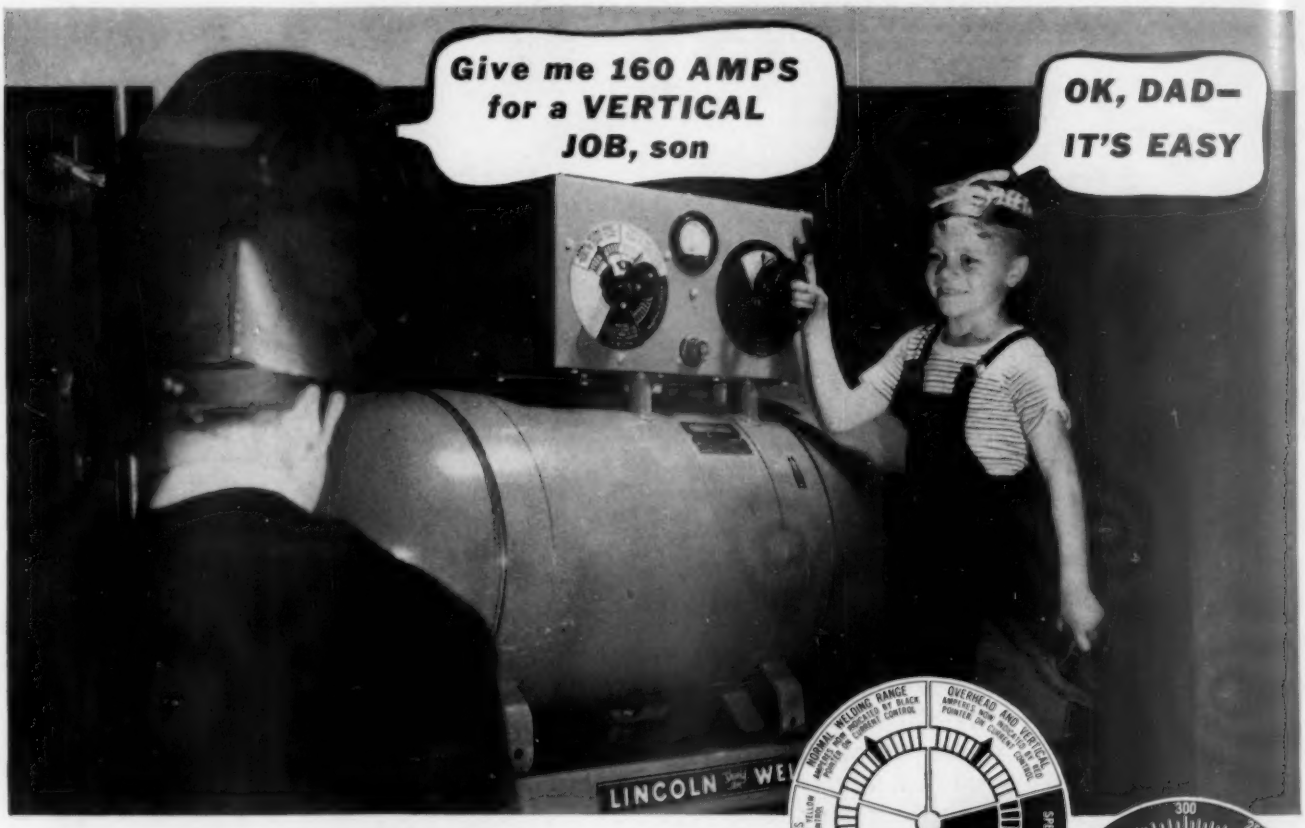
In any field knowing what people want is half the battle. The job that then remains is to try and give them what they want. This is now our job. For example, we find that interest in processes and applications is widely diversified. It does not appear that any one process of welding commands substantially more reader interest than certain other processes. It is true, however, that a few processes have comparatively slight reader interest. Shop problems and the economic aspects of welding and cutting processes need to be emphasized more in planning future editorial articles. We will search for more down-to-earth how-to-do-it material.

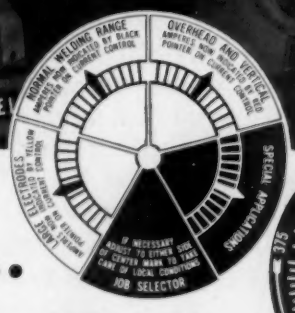
We were pleasantly surprised to find that among manufacturing and public service industries we have an average of 5.5 readers per copy. Among welding repair shops we have 2.6 readers per copy. It is, indeed, gratifying to find that readership is much more extensive than circulation of copies.

Welding and cutting processes are used in so many different industries that only by means of a reader survey is it possible for us to determine the relative importance of the different industry applications. We found, for example, that 46.5% of our readers are engaged in production welding or working for public service industries, such as railroads, electric power companies, water supply systems, etc. We found that welding repair shops represent 37.4% of our circulation. Of greater significance, however, is the analysis of that group of readers who are using welding primarily as a production or construction tool. About one-fourth of this group use welding in the manufacture of boilers, pressure vessels, tanks, piping, fittings, etc. Another 25% of this group use welding in the fabrication of machinery. Next in importance are contractors specializing on welding fabrication, 18.8%. Railroad transportation, both steam and electric, and manufacture of equipment for the railroads accounts for 10.8% of this group. Approximately the same number use welding in the petroleum industry—production, refining, pipe line construction, etc. Slightly less than 10% of our readers use welding in the process industries, such as paper mills, chemical plants, etc. Of the remaining industries using welding and cutting processes, the important ones are steel production and fabrication, mining, quarrying, road building, government construction and building of ships, barges, tugs, etc.

This analysis by industries will be extremely helpful in selecting editorial material that will have "bread and butter" appeal.

Another very gratifying result of our editorial survey came something as a surprise. We found that slightly more than 30% of our readers in the manufacturing group are carrying engineering responsibilities, either in design, welding procedure, test, development work, or combinations of these responsibilities. As a consequence we feel more keenly aware of our own responsibility in planning the editorial pages to give these men the types of articles they will find most helpful.





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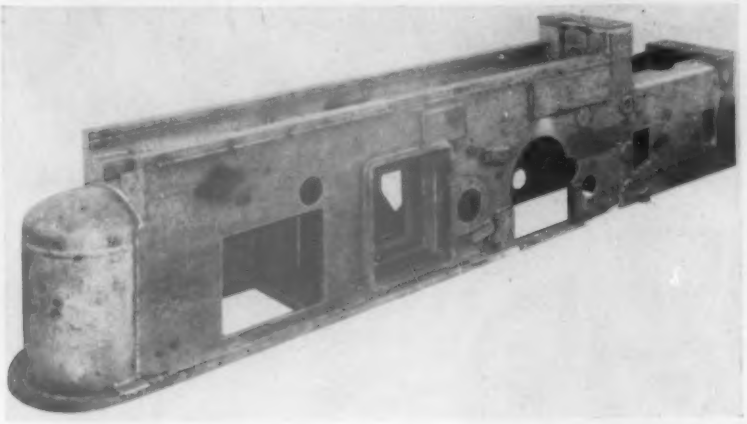

Fig. 15—Machine tool base flame cut and welded—About 35 ft. of flame cutting used on this base—Weight 4000 lbs.

Flame-cut shapes and arc welding are

Cutting Fabrication Costs

★ Part 2—More examples illustrating weight savings—Excellent physical properties and greater uniformity of rolled steel are fully utilized when welding is employed*

FIGURE 15 IS A MACHINE tool base including high-pressure tank, 14 ft. 6 in. long and 24 in. wide, flame-cut and welded. The base represents about 35 ft. of flame cutting, and weighs 4,000 lb. Here again the same method of flame cutting was employed not only on the openings cut integrally, but also on both sides of the side plates to produce a uniform dimension throughout. These top and bottom cuts formed the surfaces to which the top and bottom bars were welded.

Figure 16 shows the back of frame for a special milling machine. All flush joints were scarfed for welding. Weight, 2,600 lb.

Figure 17 is the front of frame for the milling machine with ways of 0.40 to 0.50 per cent carbon steel, bevel cut to reduce subsequent machining to a minimum. All flush joints were scarfed for welding. This is the front of the machine shown in Fig. 16. Here again flame cutting was used but not with as great evidence of accurate cutting on the outside as on some of the previous examples shown, although accuracy had to be maintained on the cutting of conventional ribs and diaphragms used in the interior construction to insure smoothness of the outside surfaces. Cutting of the 0.40 to 0.50 per cent carbon steel ways was done in such manner that cutting for one 45-deg. bevel produced two pieces, each carrying the desired beveled surface. Thus, subsequent machining was reduced to a minimum.

Figure 18 is a bed for a twin lathe with coolant tanks integral with the base, flame-cut from ¾-in. and 1-in. plate for the side walls and 2-in. steel for the top plate. Length overall 8 ft. and weight 6,000 lbs. Due to the sym-

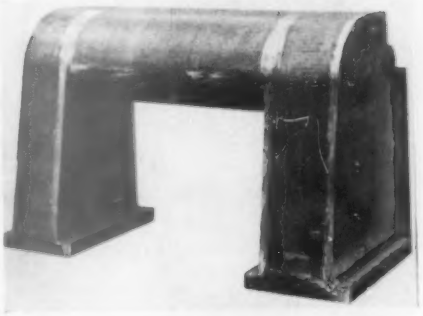

Fig. 16—Rear of frame for a special milling machine—Weight, 26000 lbs.

Fig. 17—Front of milling machine frame with "ways" bevel cut by flame to reduce subsequent machining.

*This is a continuation of the article on pages 51-56 of the September, 1938 issue. Richard W. Sternke in Figures 15 to 21 inclusive describes advantages as applied to machine frames.

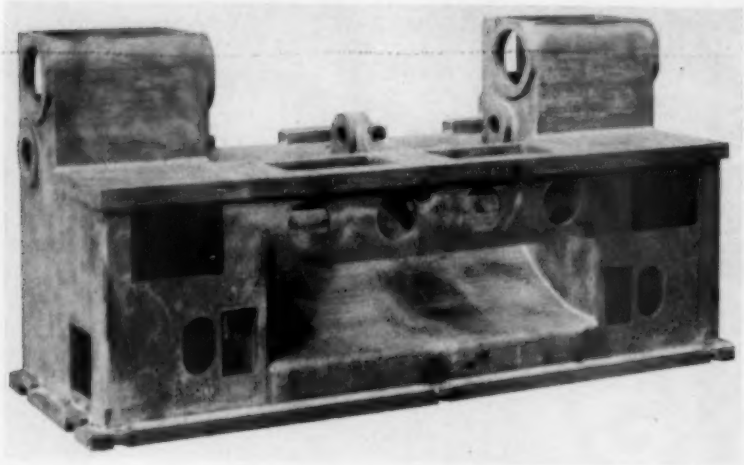

Fig. 18—Twin lathe bed flame cut from ¾-in. and 1-in. plate for side walls and 2-in. plate for the top.

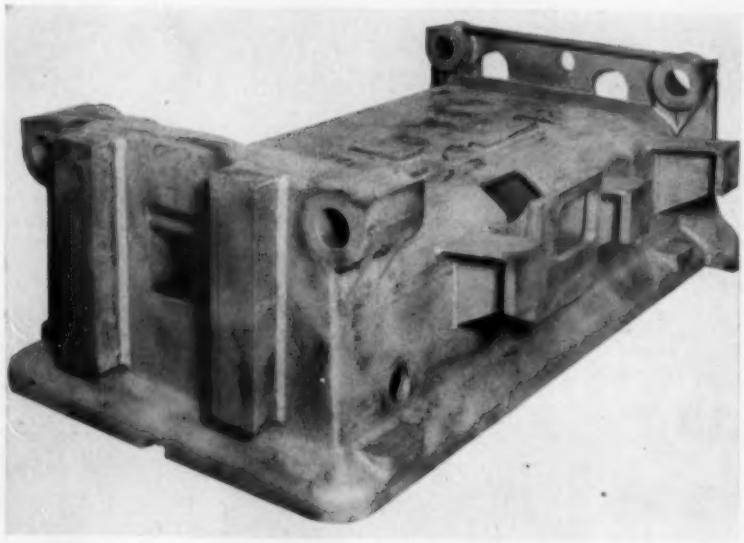

Fig. 19—In fabricating this extension to an existing machine it was necessary to duplicate the lines of a casting.

Fig. 20 — Grinding machine frame flame-cut from ¾-in. steel. The 45-deg. bevels were flame-cut from high carbon-steel.

metrical section of the component parts, cutting was done before welding without undue distortion. This applies especially to the four component plates forming the top and front of the assembly. In other words, a slight distortion caused by flame cutting could be compensated for in the tacking set-up and welding.

Duplicate Casting Contour

Figure 19 is a machine bed wing, 42 in. by 72 in., flame-cut and assembled by welding. Weight 3,100 lbs. It was necessary in fabricating this extension to an existing machine to duplicate the lines of a casting as will be noted particularly at the base. Design and the contour of this particular bed piece lend themselves admirably to flame cutting, particularly the steel hubs used at the top. These were 8 in. long, and the holes were flame cut within ½-in. of the desired diameter. The corner pieces at the bottom were fabricated separately, and then welded in, producing the smooth contour of a cast base.

Cutting 45-Deg. Bevels

Figure 20 is a frame for a special grinding machine flame cut from ¾-in. steel for the side walls. Six sets of high carbon steel ways were flame cut with 45-deg. bevels to reduce machining and then welded in place. The peculiar shape of this special grinding base was easily accomplished by flame cutting. Construction as shown in the front view, including the 45-deg. bevels cut from high-carbon steel, was readily accomplished.

Actuator Base

Figure 21 is an actuator base flame-cut from ½-in. side walls, ½-in. bottom plate, and ⅝-in. top plate. The base is 23 ft. 1 in. long, 9 ft. 6½ in. wide, 4 ft. high. The base contains high-pressure piping with welded joints torch cut to fit. A total of 2,140 cu. ft. of oxygen and 432 cu. ft. of acetylene were consumed in the cutting operations. This job for the Bonneville Dam contains several compartments which were connected by over 180 ft. of pipe. It was tested, when assembled, to hydraulic pressure, double the normal requirements, without developing a single leak. The total weight of the base was 30,000 lbs. when completed.

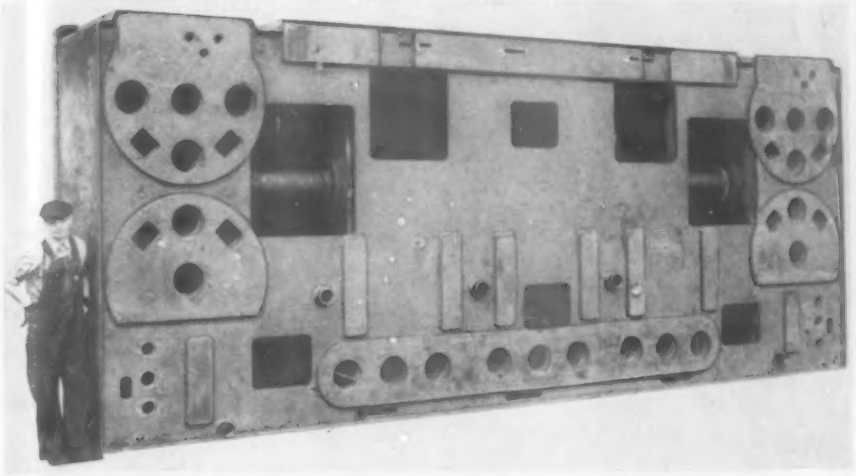

Fig. 21—Actuator base for Bonneville Dam project. Contains over 180 ft. of welded high-pressure piping.

Unique Barrel Cam Cutting Operation

★ When giving consideration to shape cutting, most engineers would hardly think of a flame-cutting machine as being readily adaptable to the production of accurate flame cut shapes other than those that can be made from flat steel plates or slabs. The photographs (Figs. 22 to 25) show an ingenious set-up by which a machinery fabricator accurately flame cut, cylinder or barrel cams for an automatic machine, with substantial time and cost savings.

Making the flame-cutting machine operate in three dimensions to produce accurate cuts in a curved shape is an interesting development which may have possibilities not immediately apparent. One of the first applications of the cutting torch was cutting plate cams for an automatic screw machine some 20 years ago. Cutting these cams was simply a matter of following a layout on a flat steel plate.

Barrel or cylinder cams are used in many automatic machine tools and other machines requiring movements of slides that cannot be accomplished readily by rack-and-pinion or crank motion. The first automatic screw machine built in the early 80's utilized barrel cams to operate the tool slides. The cam here described is a husky job, designed for heavy duty and requiring accurately shaped working faces. These were ingeniously produced by the torch with comparatively simple auxiliary equipment.

The operation is unique for at least one reason—the magnetic tracing device was used, not only for its designed purpose, but also as the sole motive power for turning the special set-up weighing approximately 700 lbs. The set-up, as shown in the illustrations, consisted of a cylindrical framework mounted on ball-bearing "balancing ways," which served as the mounting for a master templet and the cam blank to be cut.

Figure 22 shows the finished job of two pieces, known as "inside cam" or barrel cam sections for a Bliss No. 315 beader, and is made from 1¼-in. low-carbon machine steel plate. The 1¼-in. flat plate was first cut to rectangular shape, bent cold to semi-

Fig. 22—Barrel cam section for a Bliss beader which was flame cut after plate was curved to shape.

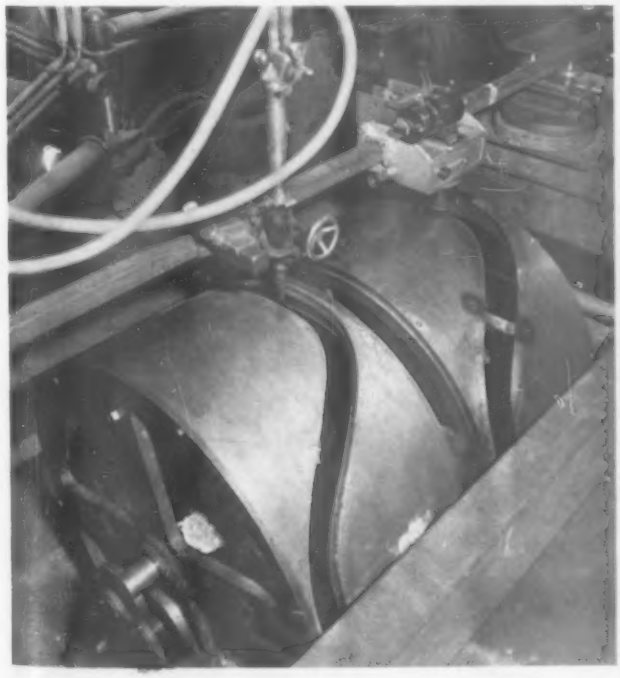

Fig. 23—Barrel cam after being cut (left) mounted alongside of "master" cam. Note magnetic tracing device engaging "master" cam.

Fig. 24—Making the "cut" while the cam was rotated by the frictional drive of the magnetic tracing unit.

circular shape, annealed and then finish turned inside and outside on a lathe. Fig. 23 shows the cam after being cut, and the master cam alongside, underneath the magnetic tracing device.

The master cam was made flat of 3/32-in. cold-rolled sheet and then bent to the same radius as the cam to be made. The opening for the magnetic roller was bridged with stiffeners shaped so as not to interfere with the roller. The master cam was then graduated to show how many thirty-seconds inch off center the cutting torch should be at any given point in order that the sides of the cuts would be parallel throughout the curves. The set-up works in conjunction with another fixture shown beyond the magnetic tracing device as follows:

This fixture, mounted on the work table, contacted with the torch bar through rollers, front and back, to provide lateral adjustments of the torch-bar carrying the magnetic tracing device and the cutting torch. The cross-slide screw was made 16 threads per inch so that one-half turn of the crank would set the cutting torch 1/32-in. off center. The torch was mounted in an adapter so that the torch and the magnetic roller could be set at the start to the same center line. The assembly was balanced by eccentric adjustable machine steel bars, and was placed in accurate alignment with the torch-bar.

The master cam and the work piece were turned together as one unit while the cut progressed. The torch was only permitted lateral movement by the master cam. Rotary propulsion was accomplished by the traction of the magentic roller bearing against the edges of the master cam.

Although four men appear in Fig. 24 and Fig. 25, only two were actually necessary for the cutting operation, one to control the off-center position of the cutting torch, and the other to take care of the round steel bar balancing weights, visible in Fig. 25 These had to be adjusted on their eccentric centers to compensate for the kerf metal cut from the work piece. This kerf metal amounted to four pounds for the entire operation. Cutting speed was 14 in. per min. If this cam job had been done on a boring mill it is claimed that it would have taken 40 hours, plus two days, or 16 hours, fitting time.

The fixtures for flame cutting, including the master cam, cost $300, and it was only necessary to make three sets to balance this first cost.

Welded Power Presses for Automotive Industry

★ Clearing Machine Corp., 6499 W. 65th St., Chicago, Ill., is a manufacturer of heavy power presses for the automotive industry and is equipped to do contract welding of heavy machinery parts. The welding department is well equipped with the latest type of flame cutting machines and welding apparatus. The shop is equipped with a large annealing furnace for relieving stresses in welded structures. Cranes and hoists in the shop can handle machine frames up to 75 tons.

Clearing Machine Corp., renders a complete service in welded fabrication, including the final machining to close tolerances. The shop layout is designed for large-scale production of welded assemblies of small or medium size up to the heaviest parts capable of being handled by the cranes and

Fig. 26—Large shape-cutting machine has a rectangular cutting range up to 6 ft. wide and 28 ft. long.

Fig. 25—The round steel balancing weights are visible in the foreground. They are used to compensate for the kerf metal cut from the work piece.

Fig. 27—Two cutting torches on the large shape-cutting machine making simultaneous cuts.

Fig. 28—One of the four portable type flame-cutting machines for straight and circular cutting.

hoists. The experience of this fabricating shop frequently enables them to suggest changes in design to obtain greater strength or to permit better and faster welding. These suggestions often enable the customer to realize sizeable economies in production.

The cutting department is equipped with a large shape-cutting machine for the bigger plates and irregular shapes used on Clearing presses. This department also has four portable-type flame-cutting machines for straight and circular cutting. The large machine is shown in Figs. 26 and 27, while one of the small portable units is shown in Fig. 28.

The plates for Clearing presses vary from ¼ in. to 12 in. in thickness. The large plates are shape cut to a very close tolerance on the large shape-cutting machine, which has a rectangular cutting range up to 6 ft. wide and 28 ft. long. Majority of shapes cut by this machine are cut from a drawing placed on the template table. When several identically-shaped plates are needed, a simple, inexpensive plywood template is used.

The cutting machine is set up in such a manner that continuous cutting is possible. A crew sets up the plate and drawing at one end of the template table, while the operator is cutting at the other end. As soon as the operator is through cutting, he moves to the new set-up in a few seconds and resumes cutting. Thus, total cutting costs are reduced to a minimum.

Clearing welded steel presses range in capacity from 100 to more than 3,000 tons. They are known as crankless presses and are designed for single, double or triple action. In other words, a Clearing press may have a single slide, two slides independently controlled, or three slides independently operated. This design has found many applications in the automotive industry, particularly in the shaping of automobile body sheets. An important feature of Clearing presses is the all-welded steel construction which provides maximum strength and rigidity without excessive bulk or weight. Absence of deflection with welded construction makes it possible to employ tremendous power with a high degree of accuracy. The design of

Fig. 30—Front of 1600-ton welded Clearing press. Distance between uprights 200 in.

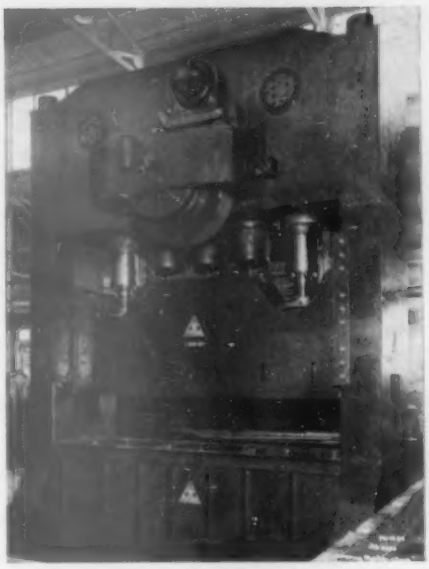

Fig. 31—Rear of 1600-ton single-action Clearing press (same press as shown in Fig. 30). Used for hot pressing; slide stops at bottom of stroke while work cools.

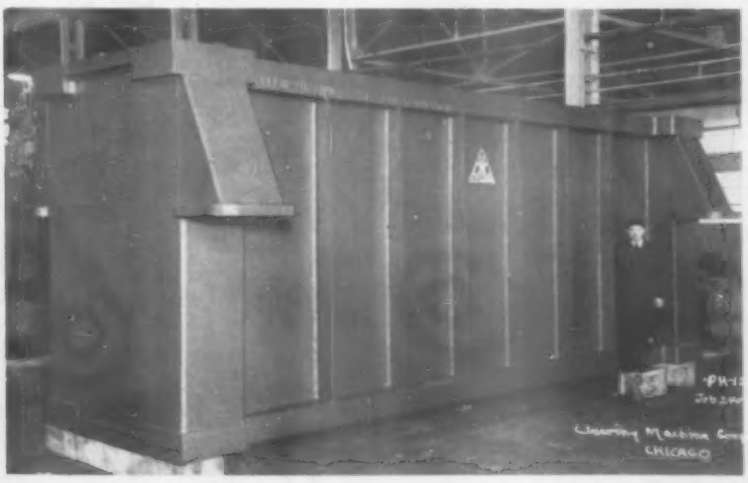

Fig. 29—Welded bed for 2000-ton Clearing press. Weight 120,000 lbs. Size—116 in. high, 280 in. long, 115 in. in overall width.

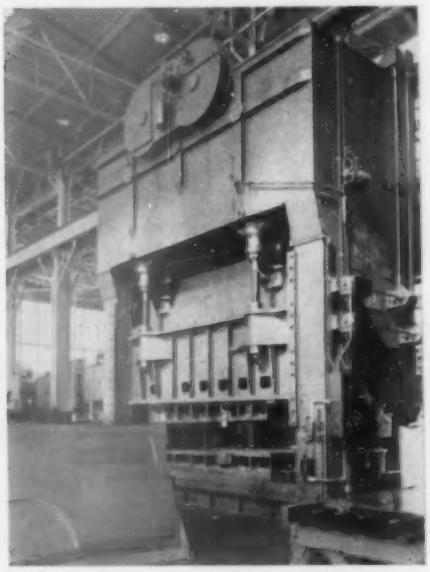

Fig. 32—All-welded 900-ton Clearing double-action press. Distance between uprights—208 in.

these presses assures parallel alignment of the slides with each other and with the bed of the press. Large steel plungers running in bronze bearings located in the crown guide the slides.

Clearing Machine Corp. prefers welded construction of heavy presses for the following reasons:

(1) The higher modulus of elasticity of rolled steel as compared to cast-iron gives necessary rigidity with almost a third less weight.

(2) Higher tensile strength of rolled steel in comparison with cast-iron.

(3) High uniformity of rolled steel as compared with cast-iron, which is liable to have blow holes and sand inclusions.

(4) With welded steel construction metal can be distributed exactly where needed and structural members need not be unduly clumsy to meet the technical requirements of the cast-iron foundry.

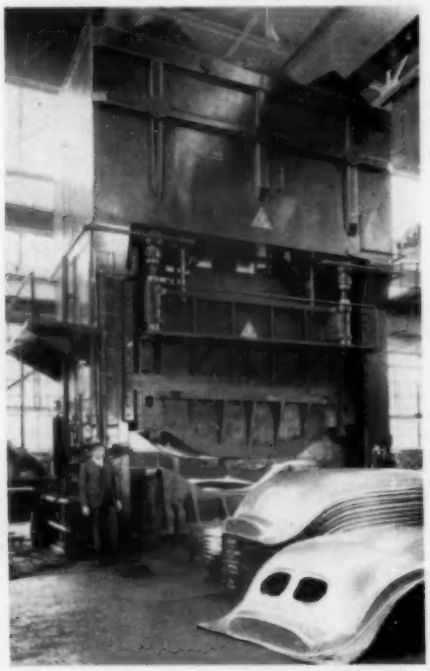

Fig. 33—All-welded 1500-ton Clearing triple-action press weighing about 525,000 lbs. A large part of the press is below the floor line.

» «

Ignitron Current Control Modernizes Resistance Welding

By E. H. VEDDER*

REDUCTION OF REJECTS: The natural result of improved quality, as previously discussed, is the reduction of rejects. Many of the more intangible factors resulting are less production delay, and less service complaints. Many of these factors are difficult to evaluate completely except the actual reduction of scrap, which is in many cases as great as from 10% to 1%.

INCREASES PRODUCTION: The increase of production resulting from accurate timing manifests itself in several ways such as:

1. Reduced outage time resulting from electrode dressing, cut-and-try adjustments, and contactor and mechanical timer repairs.
2. Operator efficiency is improved more than in proportion to reduction of outage time by removing uncertainty of results.

*Final section of Mr. Vedder's authoritative article, the first section of which appeared in the September, 1938 issue, pages 31-34. Mr. Vedder is an engineer with Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

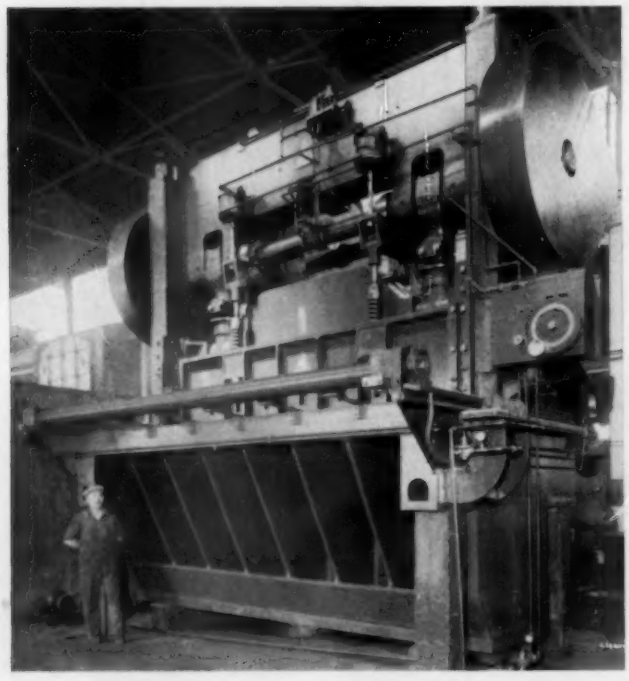

Fig. 34—Special 600-ton Clearing press for automatic manufacture of heavy metal lath. Main structural members are welded.

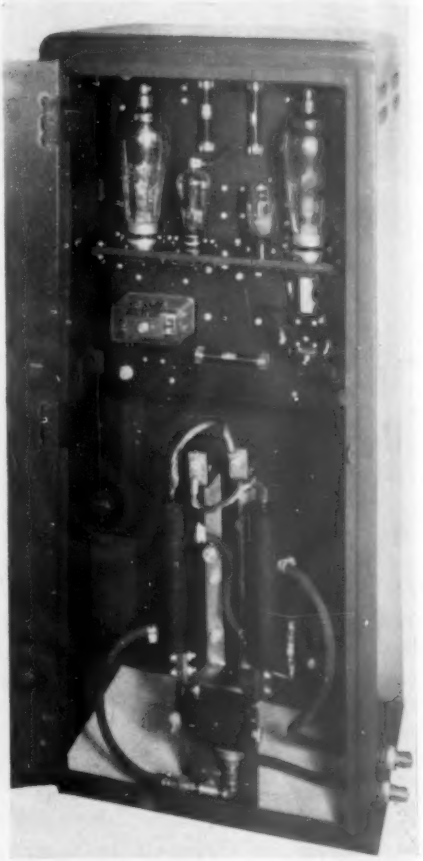

Fig. 9A—Ignitron spot welding timer using the sealed-off type of metal tubes

3. As a result of (2), rate of spot welding can be increased.
4. Seam welding lineal speeds can often be increased by more rapid and accurate interrupting rates.
5. Machine can be placed on production line basis because of increased dependability.

All of these features are being realized in many modern metal fabricating plants.

Most of the timing devices used in the past have relied upon magnetic contactors to close and interrupt the welding current. These are relatively inexpensive, but their use is limited to the more readily weldable materials and cannot be successfully used for

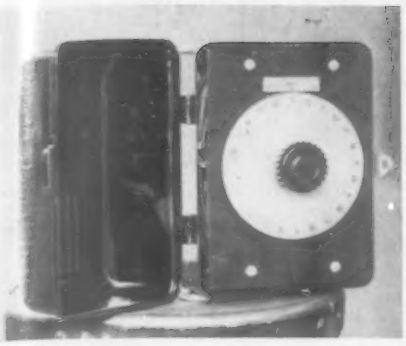

Fig. 9B—Heat control adjuster for ignitron timer.

seam welding. Inherent accuracy limitations often preclude their use in the new short-time welding with its exacting requirements.

Ignitron Spot Welding Timer

The ignitron spot welding timer, Fig. 9A, has repeatedly proved its usefulness for precision spot, projection or butt welding. This timer inherently operates in terms of cycles or in 1/60 sec. increments of welding current. It can be adjusted to deliver power to the welding machine for a timed interval of an exact number of cycles within a range of from 1 to 30 or more cycles. If the particular application demands it, timing may be adjusted in ½ cycle increments although such close adjustment is not normally required. The ignitron power tubes simulate the action of a single-pole, single-throw switch which is closed for a definite length of time and reopened. They operate noiselessly and without any arc burning. The primary current of the welding machine is carried and interrupted entirely by ignitron power tubes. No mechanical or other semi-mechanical device can vary the accuracy of timing.

The ignitron tube consists of a vacuum-tight enclosure of metal or glass in the bottom of which is a pool of mercury that serves as one electrode. The other power electrode consists of a graphite block located a short distance above the mercury pool and of course insulated from the metal enclosure. Instead of a grid as used in most tubes previously, an igniter or "spark plug" is used. This igniter is insulated from the two main electrodes, although partially immersed in the mercury pool. The ignitron will not conduct current until a small ignition current is passed through the igniter to the mercury pool. The ignitron tube then instantly becomes conducting. For welding control, the timing circuit supplies current to the igniter at the beginning of each half-cycle during which welding current is desired, since the tube must be re-ignited for each half-cycle of power conduction. Since the tube is a rectifier, two are reverse-parallel connected in the a-c. primary circuit of the welding machine transformer, one to carry the positive half-cycles and the other the negative half-cycles.

The ignitron spot welding circuit is shown schematically in Fig. 7. The timing circuit depends upon a condenser discharge. Closure of the weld initiating contact energizes the timing tube circuit. The timing tube breaks down at a definite time during the cycle determined by the setting of the power factor control. This instantly causes the thyratron control tubes which are used to energize the igniter to become conducting. The ignitron power tubes are, therefore, energized. At the same time, a capacitor-resistor circuit is energized and after a predetermined number of cycles, depending on the adjustment, the timing tubes start passing current and stop the thyratron igniter tubes. The ignitrons then stop conducting at the end of the half cycle. In order that the sequence may be reinitiated, it is necessary to open the weld initiating contact. This opens the timing circuit, discharges the timing capacitor and resets all of the tubes to the initial starting condition.

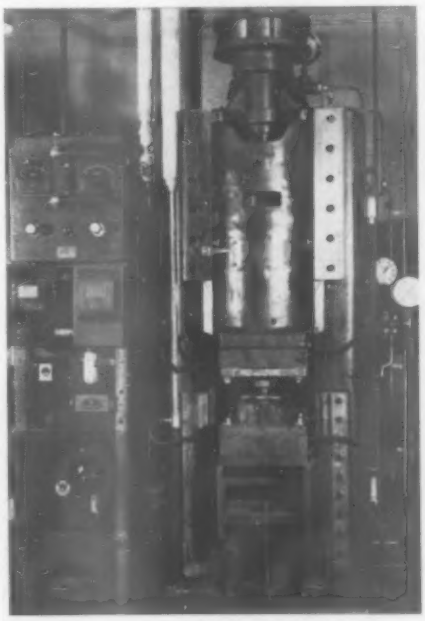

Fig. 10—Consistency indicator panel (upper left) indicates exactness of reproduction of welding time and current on each spot weld.

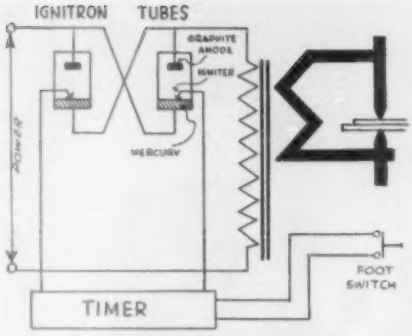

Fig. 7—Schematic wiring diagram of resistance welder with ignitron control.

For seam welding, a rapidly repeating type of timing control circuit is required which will operate to deliver interrupted current so long as the control circuit is closed.

Ignitron Seam Welding Timer

The ignitron power circuit for seam welding is the same as for spot welding as shown in the schematic circuit, Fig. 7. The timer portion of the device is different and comprises a synchronously-driven induction generator which provides timing in place of the capacitor discharge circuit used for spot welding. The rotor is a disk containing 120 holes at the periphery, as shown in Fig. 8B.* This disk is driven through a gear reduction at exactly one revolution per second by a synchronous motor. Each hole passes a point on the stator in a time corresponding to one-half cycle of current. The timing is adjusted by plugging steel pins into each hole during which welding current is desired. These pins pass between the narrow poles of the stator which is a permanent magnet with coils wound on it. These coils energize the ignitron power tubes at the passage of each pin through the magnet air gap. For example, six successive holes may be plugged and four left open, and so on around the disk when welding current will be delivered in 3 cycle pulses with 2 cycles interval between. In this manner, the timing and interrupting rates are both adjustable. This type of control is very desirable because the time adjustment is mechanical in nature, visual, accurate and simple.

Ignitron timing permits other desirable control features in addition to the major ones of timing accuracy. These additional features permit great flexibility. For instance, "heat," or weld-

*Page 34, September, 1938 issue.

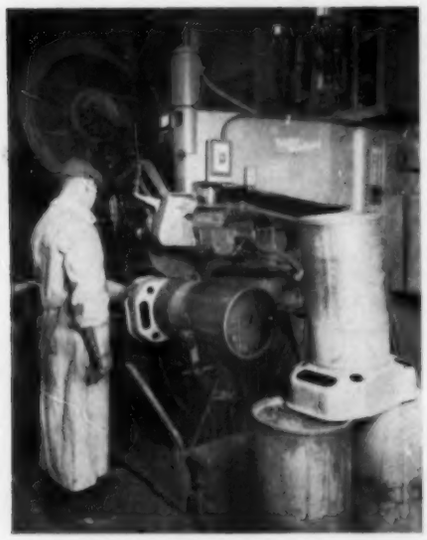

Fig. 11—Seam welding machine and timer for making lateral or circular seams on tanks.

ing current magnitude can be varied by operation of the small heat control adjuster shown in Fig. 9B. This can be remotely mounted on the machine as can also the time control dials.

Ignitron Welding Heat Control

The magnitude of welding current can be varied as well as the time of its flow by the same pair of ignitron tubes. This is accomplished by delaying the ignition of each power tube for each half cycle of welding current desired so as to reduce the heating value of current. This is similar to the reduced power output of an automobile motor with retarded spark. Such ignition delay results in intervals of zero current between the successive half-cycles of welding current and also decreases their crest magnitude because of load inductance. Welding heat or current can thus be controlled with great accuracy without use of taps on the welding transformer.

Some of the advantages of delayed ignition heat control are:

1. Economies in tap changing equipment.
2. Heat setting change between successive spot welds.
3. Continuous change in heat value to suit gage tapering of seam welded stock.
4. "Tuning in" of heat during welding to find proper settings.
5. Remote and easily operated heat adjustment placed near the operator and adjusted by the finger tips.
6. Compensation for reduction of welding current as magnetic materials are inserted into welding machine throat during the welding operation.

Consistency Indicator

It is often desirable to be able to check each weld for consistency of current and time. Figure 10 shows a device which accomplishes this and also indicates current values. This device consists of a standard ammeter connected to the welding machine primary circuit through a current transformer. Because of the short weld duration, the ammeter does not reach a stable point by the time the weld is finished. This ballistic action permits a variation of the high point of the swing if either current or time varies. Thus, if the current or time is greater than desired, the ammeter will swing further, or if less than desired, will swing less.

Attached to the ammeter needle is a mirror which reflects a beam of light to a phototube and rings a bell if the current and time and therefore, the ammeter swing, are normal. If the swing is too little—low time or current—the bell does not ring. If the swing is too great—high time or current—the bell rings twice; once on the way up and once on the way back.

It will be apparent from the sample welds, samples of installations, and many available features which have been described that resistance welding is now assuming its rightful place in the production line and is being trusted more and more where quality and low cost are of importance. Development of this type of control is extremely rapid, not only as regards new features, but also the cost is being radically reduced, thus permitting its use more broadly, where previously only the cheapest form of control could be justified.

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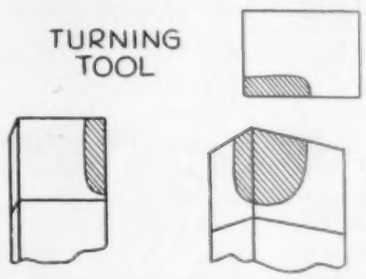
DRAVO CORP., Pittsburgh, Pa., has received an order from the Ethyl-Dow Chemical Co., Wilmington, N. C., for a welded standard 100 ft. x 26 ft. x 6 ft. 6 in. flush-deck type steel barge to be fabricated at the Neville Island shops, and assembled at the Dravo ship yard on the Christiana River at Wilmington, Del.

Brazing Tungsten Carbide Tipped Tools

By L. THOMAS

★ The tungsten carbide tipped tool in the form of drills, milling cutters, form tools, reamers, etc., are being increasingly used in many trades. They are eminently suitable for high-speed production with long tool life between grinds, and in addition to use on cast-iron and non-ferrous materials generally, they have with great advantage been used on plastics, hard rubber, marble, glass, slate, porcelain and erinoid. For those that wish to make up these tools for their own individual requirements, the procedure is fairly simple and consists of brazing a tungsten carbide tip to a steel shank.



How to apply tungsten carbide tips to carbon steel tool shanks—Lathe turning tool is shown.

The following points however are important and should be carefully carried out.

For the shank, a steel of 50% carbon is most suitable. This is carefully milled to suit the tip so that the tip has proper support, and all faces of the tip that come into contact with the shank are ground or finished. Both tip and shank are cleaned, and freed of grease. This should be done thoroughly, for even the perspiration from the hand is sufficient to cause a defective braze. Gasoline is not good enough for the job—a chemical cleaner like tri-chlor-ethylene or carbon tetra-chloride should be used.

Place a piece of the copper and a little unfused borax on the tip which is placed in position on the shank. Place the whole in a small muffle made by grouping together a few fire bricks and heat with the oxy-acetyelene blowpipe. Continue to feed borax on the tip with a rod. When the copper melts press the tip with a rod so that it moves slightly on its seating squeezing out excess copper and insuring a good joint. Place the tool in powdered electrode carbon so it can cool off slowly.

Discussion of welded

pipe joint designs for

High Pressure Power Piping

SINCE PUBLICATION of the article "Welding Procedure for Carbon-Molybdenum High-Pressure Power Piping," in the July and August issues, we have received a letter from Sabin Crocker, senior engineer of the Detroit Edison Co. Mr. Crocker presents his comments on certain technical points covered in this article. It is evident from Mr. Crocker's criticisms that the position of the Detroit Edison Co. in regard to the use of backing rings was misstated:

"I have reference to the statement that 'The chill ring is not recessed in the pipe wall in this design because in an investigation made for The Detroit Edison Co. at the University of Michigan, it was definitely determined that the slight reduction in inside diameter of the pipe caused by an unrecessed chill ring has no appreciable effect on steam flow.' While we have had creep tests made on weld metal at the University of Michigan no tests have been made there for us with a view to determining the pressure drop due to unrecessed backing rings.

"Under some conditions, on the contrary, we feel that excessive pressure drops might be encountered. Use of the backing ring shown in Fig. 1 of the article on a 2½ in. Schedule 40 pipe, for instance, would reduce the inside area of the pipe over 36%, and undoubtedly would produce an appreciable pressure drop. Our practice heretofore has been to use a ⅛ in. thick backing ring on pipe sizes from 2½ to 5 in. inclusive, and ¼ in. for sizes 6 in. and larger. For the larger sizes we have seen no indication of excessive pressure drop arising from ¼ in. unrecessed backing rings and agree that the expense of upsetting pipe ends in order to fully recess the rings is not justified. I should like to point out, however, that the restriction resulting from the rings in power plant piping is, at the present, a more or less unknown quantity as the individual effect of the backing rings on pressure drop cannot be segregated. In boiler feed piping, for instance the emergency conditions for which the pump is selected are such that any slight additional pressure drop due to the backing rings would have no appreciable effect on the operating characteristics of the pump.

"We have been favorably impressed with the use of partially recessed backing rings of thin section (around ⅛ to 3/16 in. thick) where advantage is taken of the over-thickness of pipe wall afforded by mill tolerance in order to provide a shallow recess or counterbore. This serves the dual purpose of trueing up the pipe ends so that the backing ring has a snugger fit and at the same time partially buries the ring. This is in line with your statement that, 'Since pipe walls may vary slightly in thickness and pipe is seldom perfectly round, it is frequently necessary when using chill rings to machine the pipe ends in order to provide true round contours and assure a good fit of the rings.' We have recently adopted a design similar to the 10 deg. bevelled ring described by F. C. Fantz in a recent A.W.S. paper.

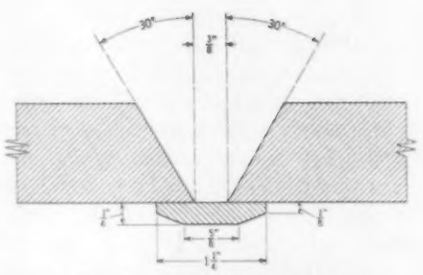


Fig. 1—Basic pipe joint design.

"At another place it is stated that 'Chill rings are generally made of the same material as the pipe being welded.' While alloy steel rings may have been used in some instances by others in welding alloy pipe, the need for using them is questionable and I doubt whether this is general practice. For instance we are using plain carbon steel backing rings in welding the carbon-moly superheated steam piping for our 865 lb., 910 deg. F. extension of the Delray plant.

"In view of the miscellaneous variety of bevelled ends proposed in the article, I wonder whether the author was aware that Sectional Committee B16 of the American Standards Association adopted last December, subject to letter ballot approval, a recommended practice standard for such bevels which differs from the proposals, outlined in your article, as to degree of bevel, root spacing, and use

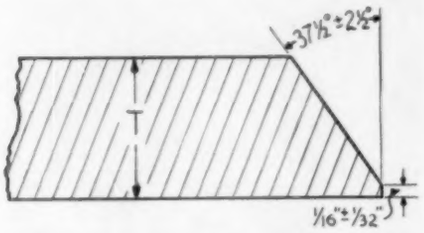


Fig. 2A—Type of bevel used on pipe sections 3/16 in. to ¾ in. thick. For oxy-acetylene and arc welding.

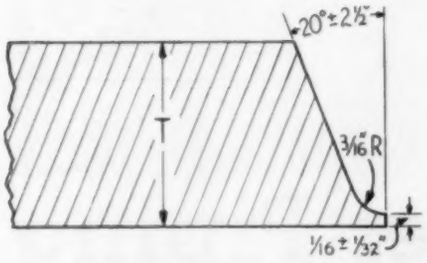


Fig. 2B—Type of groove used on pipe sections heavier than ¾ in. thick. For arc welding only. (Both of these designs are a proposed A.S.A. Standard, Sectional Committee B16).

of a land. Figure 2 shows this recommended practice. I might explain that the committee considered non-symmetrical bevels, such as Fig. 4 of the article, for use on vertical pipes and discarded the idea as unnecessary and tending to produce confusion in fabrication and erection.

"The author's observations about the need for wide root spacing and the omission of lands in order to obtain thorough fusion between the pipe ends, backing ring and weld proper are most interesting, although not corroborated so far by our own experience. The case would be presented more conclusively if actual macrographs of etched weld sections to show lack of fusion had been used.

"May I add a word of protest against designating backing rings as 'chill' rings. I frequently catch myself calling them 'chill' rings as the word rolls off the tongue (or pencil) easily, but really the last thing we want them to do is to chill the weld. Hence I feel that engineers should take the lead in encouraging the trade to use a more properly descriptive term, and until a better name is coined I should prefer 'backing' ring to 'chill' ring.

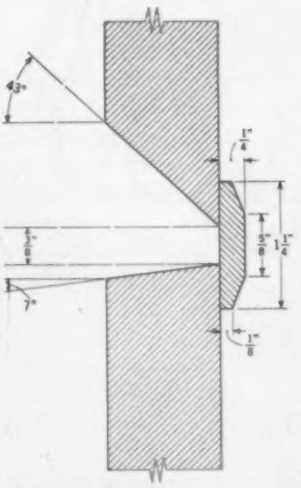
"Your article contains other statements on which we wish to offer further comment. On page 25, for instance, it is stated that typical physical properties of a 0.10 to 0.20% carbon, ½% molybdenum steel are:

Ultimate strength.....	75,000 psi.
Yield point	45,000 psi.

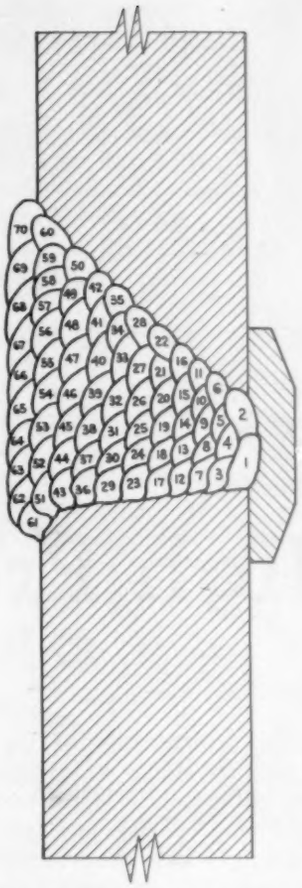
"The present A.S.T.M. specifications for carbon-molybdenum alloy-steel pipe, A206-37T, requires a minimum tensile strength of 55,000 psi. with a yield point of 30,000 psi. minimum. The 1936 version of this specification called for a 60,000 psi. minimum tensile strength which, it was found by experience, could not be obtained successfully in the normalized and drawn-product which is the treatment customarily given pipe for power-plant service. The requirement was then reduced to 55,000. The 'typical' tensile strength and yield point listed in your article for carbon-molybdenum steel are entirely out of line with the customary commercial product.

"Another sentence states that 'carbon-molybdenum steel is to some extent corrosion resisting. This statement is so broad that exception cannot be taken literally, but the implication is incorrect. Carbon-molybdenum steel pipe of the analysis you quote is considered to be no more corrosion-resisting than plain carbon steel at temperatures up to 1000 deg. F. according to information published by the National Tube Co. and others. At the present time, we are conducting tests to determine the relative corrosion resistance to steam of various steels under actual service conditions."

In view of the fact that our article on the welding of carbon molybdenum high-pressure piping was a digest of a recent bulletin on the same subject issued by Metal & Thermit Corp., we have asked J. H. Deppeler, chief engineer of that company, to present his



(Fig. 4—Modified design for welds made in the vertical position. Reprinted from July, 1938 issue, pages 25-28.)



(Fig. 9—How succeeding beads are put down on joints in the vertical fixed position. Reprinted from July, 1938 issue, pages 25-28.)

comments regarding Mr. Crocker's criticisms. Mr. Deppeler says:

"As you undoubtedly know, we developed a few years ago the carbon-molybdenum .50 electrode for welding steel of this analysis, particularly for Navy Department work and this electrode was immediately adopted for welding of rolled carbon-molybdenum steel in high temperature piping installations. It has been used quite extensively by the Ford Motor Co., the Grinnell Co., General Fire Extinguisher Co., by the New York Edison Co. and the Public Service Electric & Gas Co. of N. J., and, also, of course, by your own concern. In this work we have been called upon to instruct and train welding operators and gradually developed a joint preparation and procedure which seemed to be best for even inexperienced operators. Our field men had so much explaining of this type to do that it seemed as though it would be helpful to get out a bulletin showing the joint preparation and procedures which they had found best in the field. This bulletin was our No. 20, copy of which you probably have,

but an additional copy is attached hereto. Most of this material was gotten together during the last six months of 1937 and although the publication in bulletin form was delayed until 1938, we did not realize that the preparation differed from that finally adopted by the American Standards Association in December, 1937.

Practical Difficulties

"The difficulties which our field men had, resulted from joint preparation in which the land or shoulder was as great as ⅛ in. and the root spacing and bevel of the sides considerably less than we would like. In attempting to train inexperienced operators in making these welds in the fixed position, we naturally found that only the most experienced operators could make satisfactory welds with narrow vee's and small root spacing and that the heavy ⅛-in. land would so prevent the proper fusion of the pipe end with the backing strip that the defects outlined in our bulletin and subsequently copied in the publication in which you saw it, did actually exist and were corrected only when the land was greatly decreased, even to the extent of bringing it to a feather edge and the angle of the sides opened up and a wider root spacing used to give the operator a chance to make a sound weld especially at the root.

"As a matter of specification, there is no doubt that the feather edge which our drawings show is really the same as the properly specified land as shown in the A.S.A. drawings, that is, 1/16 in. = 1/32 in. and our own drawings will be changed in this regard so that they will correspond with the committee recommendation. The value of the larger vee opening in the committee recommendation, i.e., 75 deg., as compared with our recommendation of 60 deg. depends naturally on the root spacing. We prefer a root spacing greater than the committee's recommendation of 3/16 in. minimum and with this greater root spacing the angle of the sides could be slightly less than that recommended by the committee. The place where inexperienced operators have trouble, as we have learned in work with a great number of them in different organizations, is in the soundness of the root weld and we naturally prefer, therefore, the ⅜ in. root opening with the 60 deg. included angle than a 3/16 in. root spacing with a 75 deg. included angle. On the other hand, now that we are aware of this American standard we probably will change our drawings in this regard, also in case our bulletin No. 20 is to be reprinted. On the other hand, if this standard bevel is up for consideration in the future we would very much like an opportunity to recommend the alternative which our present drawings show.

"Our bulletin was not written as a true technical article and it was therefore not supported by photo-macrographs and bibliography as it normally would have been. Since the receipt of your letter we have taken steps to obtain, if they still exist, some of the many test specimens resulting from the qualification of operators and although we could obtain the X-ray films showing this type of defect, these alone would not be very helpful in support of our contention. We feel, however, that you would agree that, if as in the earlier work the pipe was prepared with a ⅛-in. land, that these defects referred to would be met and the conditions would be observed in photo-macrographs. The standard preparation with the 1/16-in. land would however be perfectly satisfactory, if the root spacing were wide enough to allow careful observation and manipulation in the making of the root weld.

Non-Symmetrical Bevel

"On the question of non-symmetrical bevel as shown in our Fig. 4 for use on vertical pipes, we agree that it is objectionable from the fabrication and erection standpoint. Here again in the actual practice with green operators we had enough trouble with the symmetrical bevels to cause us to recommend the unsymmetrical and in all cases where the fabricator is willing to more thoroughly train his operators to offset this erection defect, we agreed that the symmetrical bevel could be used. The advantages of the non-symmetrical bevel shown in our Fig. 4 is that if the beads are put in the order shown in Fig. 9, each bead presents no more difficulty than the running of a horizontal fillet weld which even inexperienced operators can do quite well. With the symmetrical bevel relatively few of the operators tested could pass the qualification test, because of defects on the lower bevel, due to the weld metal running down and lapping over and tending to entrap slag. The unsymmetrical overcame these difficulties and we would prefer to recommend it not necessarily as a standard, but for those fabricators who are willing to put up with the confusion in fabrication and erection.

"We are in entire agreement with you on the importance of referring to 'backing rings' as such and not as 'chill rings' and will see that this term is used hereafter. We appreciate very much your having taken the time to go into such detail in helping us and will most certainly take advantage of the information given in your letter in any future publication of this kind."

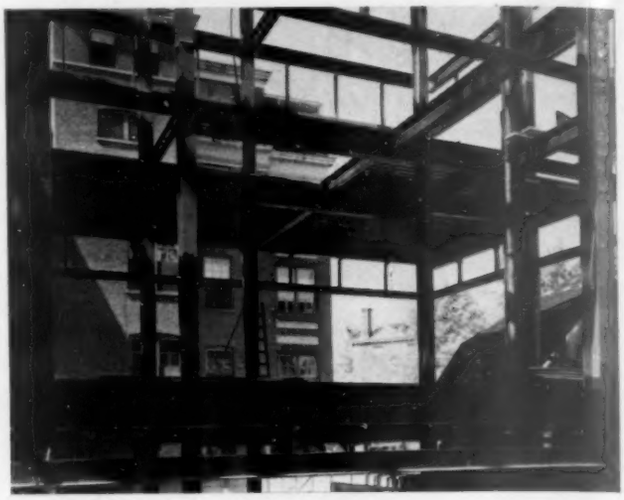
» «

Flanges of Channel Frame Form Service Ladder

★ When the usual servicing ladder used to permit the pumper to reach and oil the bearings in a well pumping unit continually showed up "among the missing" or managed to get smashed by trucks, or otherwise rendered useless, the welder converted one of the legs of the A-frame supporting the pumping rig beam into a safe and serviceable ladder, simply by welding rounds of sucker rod to the flanges of the beam at 10-in. intervals.

The ladder thus formed leads directly to the point where oil must be applied; it cannot be "borrowed" or mislaid, and is safer than an ordinary ladder. The perfectly formed toeboard made by the web of the channel, prevents the workman's foot from slipping too far on the round.

Sucker rod "rounds" welded across flanges of channel provide safe ladder for servicing bearings on this pumping rig.



Welded steel framework for addition to Ellis Hospital in Schenectady, N. Y. A welded steel cellular type floor construction was used.—Photo, courtesy of General Electric Co.

Digest of selected papers presented at

Annual A. W. S. Meeting

OF THE MORE than 40 technical papers on the program of the American Welding Society annual meeting held at the Book-Cadillac Hotel, Detroit, Mich., October 16-21, we present in this issue digests of some of the papers. These were selected from a number of digests made available by A.W.S. headquarters in time to be included in this issue. In selecting these digests we were guided by the results of our recently completed survey of reader interests and problems.

Oil Well Casing Welding

By W. "MIKE" MURPHY*

★ We are in an era that might well be called the "oil rush." In Texas, California, and Oklahoma there are large tracts of country dotted with oil wells. At the end of 1937 there were 351,000 producing wells in this country. During that year 29,000 more oil and gas wells were drilled to an average depth of 3200 ft.—deepest over 14,000 ft.—at a cost of 680 million dollars. One of the major items in the cost is steel casing pipe about a foot in diameter, which is pipe used to line the hole to protect it from caving and intrusion of water. Over 20,000 miles of casing entered oil and gas welds in 1937, and it is estimated that had the lengths of casing been welded instead of screwed together with couplings, there would have been a saving of over 5 million dollars.

Satisfactory welding methods utilizing either oxy-acetylene welding or arc welding with covered electrodes have been developed during the past year or two, as described by "Mike" Murphy. The methods are almost identical with ordinary pipe welding, which has been standard practise for many years. The pipes are vertical when the welding is done just before the joint is pushed into the drill hole. Difficulties created by the high strength of casing steel have been overcome. The most popular type of joint is the bell-and-spigot, although other types are equally satisfactory. Two or three welders work at once on each joint so that the casing is strung with unusual speed.

There are three outstanding advantages of welded casing pipe. First of all, casing beveled for welding costs less than threaded casing required for screwed joints. Second, welding is safer for the drilling crews. And lastly, the welded joint is always oil and gas tight.

*Air Reduction Sales Co.

Test for Quality of Weld

By W. J. CONLEY

★ More can be deduced about the quality of a metal by an expert examining a simple fracture, it is claimed, than by a staff of scientists using a battery of laboratory apparatus. It is in this spirit that W. J. Conley proposes to determine the quality of an arc or gas weld by nicking it with a hack saw, breaking it under a hammer, and examining the fracture. The expert examiner looks for the character of fracture, whether ductile or brittle, as well as for defects, such as slag and blow holes.

To prove his contention, Conley has subjected arc and oxy-acetylene welds in structural and corrosion-resisting steels $\frac{3}{8}$ in. thick to the standard tests involving relatively expensive specimens. At the same time, he has applied his quick shop test to these specimens. As was expected, the ranking suggested by the quick test and worked out by statistical methods was practically the same as that dictated by the results of standard tests for strength, toughness, and ductility. The conclusions drawn were that the quick nick test does not require long experience for interpretation, and that the

strength and ductility of a weld are manifested visibly in the fracture.

Welding Arcs

By C. G. SUITS*

★ Besides being the highest temperature that is handled by industry, the welding arc is one of the most elusive phenomena with which the scientist has to deal. The welding arc is the brilliant light coming from between the parts to be welded and the electrode, which may be bare or covered steel copper, aluminum, carbon, etc. Yet we do not know what occurs in the small space in which the intense blue light of the arc originates.

An admission of ignorance of this sort is an irresistible challenge to the scientist, who has accumulated a great deal of scientific information in recent years with which the welding industry has not been able to keep pace. Dr. Suits has coordinated all the recently acquired knowledge about arcs, has poked a little fun at some of the less expert research, and has added not a little of his own discoveries about arcs.

First of all, Dr. Suits distinguishes between (1) low-pressure arcs, such as the cold-light mercury vapor lamp, in which tiny particles (electrons) at a temperature of 30,000 deg. move at high speeds in a neutral gas at room temperature, and (2) high-pressure arcs in which the tiny moving particles that constitute the arc current are at the same temperature as the surrounding gas. The temperature of the high pressure arcs, of which welding arcs are one type, is 7,000 to 12,000 deg. F., which has been determined by a method involving the velocity of sound. The arc temperature, therefore, is about the same as the temperature of the sun.

The tiny particles (ions and electrons) carrying the arc current in metal arc welding move through an atmosphere of metal vapor. These particles therefore, are metallic and must come from the surface of the electrode or metal being welded. The space in which the particles acquire their current carrying characteristics is less than ½ a hundred-thousandth of an inch thick, which is still equivalent to several hundred layers of solid metal atoms. What happens in this space depends on whether the metal surface is clean or dirty. If the surface is clean it is difficult to obtain a supply of particles to form an arc, especially an arc easy for the welder to manipulate. On the other hand, if the metal is dirty, that is, oxidized, the high fields necessary for emission are produced by the surface charge on the very thin oxide film. It is this oxide film which is believed to assist the welder in maintaining his arc.

*Research Laboratory, General Electric Co., Schenectady, N. Y.

Silver Alloy Brazing

By A. M. WEIR and H. M. WEBBER*

★ The clouds of steam we often see blown in the air by electric locomotives reveal a certain dependance on steam. The steam is raised for heating and hot water in oil-fired vertical boilers that are remarkable for their compactness and high efficiency. Both of these characteristics depend upon the use of copper boiler tubes, which contain the water for the steam, and are heated by the oil flames. In turn, the copper boiler tube depends upon silver brazing for its assembly with the remainder of the steel boiler.

Brazing is a welding process in which the parts are joined by a material melting at a relatively low temperature, 1200 to 1500 deg. F. Silver brazing involves the use of a brazing metal containing 50% silver, 18% cadmium, 15.5% copper, and 16.5% zinc. The silver brazing metal is applied as a band ¼ in. wide 1/20 in. thick slipped into each hole in the boiler tube sheet. The ends of the copper tubes are then inserted into the holes, both having been brushed with flux prior to assembly. The entire boiler with nearly 2500 silver brazed joints to be made is assembled and placed as a unit into the brazing furnace.

The brazing furnace is maintained at 1200 deg. F., and is filled with 99.7% pure nitrogen. The nitrogen prevents the copper from becoming brittle. The assembled boiler is raised in two hours to 1200 deg. F., at which temperature the silver brazing melts and bonds the copper tubes to the steel boiler shell. Unlike other brazing metals, the silver alloy does not eat straight through the copper. As soon as the correct brazing temperature has been reached the boiler is cooled down and is ready for the severe service to which it is intended in passenger electric locomotives.

*Mr. Weir is with The New York Central System; Mr. Webber is connected with General Electric Co.

Residual Stresses in Pipe Welds

By E. L. ERIKSEN and I. A. WOJTASZAK*

★ Stress is simply a technical term expressing load. It is difficult at first glance to imagine why a 2-ft. length of pipe with an arc weld in the middle should be under stress or load, before any visible load has been placed on it. Yet peculiar residual stresses are created in different parts of a pipe that has been welded. The heat of welding causes the pipe to yield while hot, the yields not being completely reversed during cooling after welding. As a result, the steel in the pipe is under load after welding. These loads or residual stresses have been measured by the authors, who have also studied the effect of reheating the welds to dissipate the residual stresses.

Since stress is always accompanied by changes, although small, in dimension, the pipes were cut into pieces in several different ways, the changes in dimensions as a result of cutting being caused by release of the residual stresses. The measurements, which were made with microscope micrometers showed that welded joints in mild steel pipes of 8⅝ and 20 in. diameter, ½ and 1 in. thick, may have residual stresses up to 50,000 psi. in the larger pipe and 25,000 psi. in the smaller. Reheating the weld for 8 hr. at 1200 deg. F. reduced the residual stresses nearly to zero. These measurements show that high residual stresses may exist near welded joints in large pipe and prove that the customary "stress-relieving" heat treatment is entirely adequate.

*Both of The Department of Engineering Research, University of Michigan, Ann Arbor, Mich.

Flame Hardening

By JOHN SHEPPARD*

★ Hardened and tempered steel is the backbone of all heavy-duty, high-speed machinery, such as airplane and automobile engines. The customary procedure for hardening consists in taking the steel to a furnace, heating it to a red heat, and quenching it in oil. In flame hardening, the source of heat is taken to the steel to be treated, thus reversing the customary procedure. In other words, an oxy-acetylene torch with neutral flame is played on the part to be hardened. As soon as the

*Chief Metallurgist, Kelsey-Hayes Wheel Co.

part has reached a red heat a stream of oil or water is directed upon it to harden it. The torches described by J. Sheppard are up to 3 in. wide, consume a cubic foot of oxygen and acetylene for every 4 sq. in. of hardened area, and travel at the rate of 6 to 8 in. per minute. The quenching is done by a jet of water also delivered by the torch back of the flame.

The flame hardened part is free from scale and is not distorted in contrast with furnace hardened parts. In addition, the flame can be directed to only those areas of a gear, tool, or shaft, for instance, that require hardening. Any machine steel, tool steel, or alloy cast iron may be flame hardened, the tool steels requiring slower heating and less drastic quenching to prevent cracks. One of the greatest advantages of flame hardening is its rapidity. The entire width of a railroad rail may be hardened for a distance of 4 or 5 inches in less than two minutes.

Welding of Machine Tools

By L. NENNINGER and W. A. MADDOX*

★ Noise has always been associated with machines, particularly with the metal-cutting machines which are back of the phenomenal advance in our material culture during the past few decades. The origin of noise is vibration. Since vibration is nothing else than uncontrolled, though small, motion, a vibrating, noisy machine tool will not produce work as accurately as a non-vibrating machine.

Welding's place in machine tool construction has been earned by its ability to produce machine tools free from vibration. Cast iron, the traditional material of machine tool construction, is basically limited in design possibilities and rigidity although it has its place for intricate machines produced in very large quantities. Welded steel construction, on the other hand, is not. Provided, the welded structure is designed according to welding principles and that the welds are relieved of shrinkage stress by annealing at a black heat (1200 deg. F.), the welded machine may be expected to attain greater accuracy and freedom of vibration than the cast iron machine, and to maintain them for a longer time. Light, good-looking, welded grinders, millers, and broaches have been in service successfully for a number of years and have amply lived up to expectations of noiselessness and permanent accuracy.

*Both of Cincinnati Milling Machine and Cincinnati Grinders Inc.

Weldability of Medium-Carbon Steel

By R. W. EMERSON*

★ Welds are made nowadays in practically all metals, yet there is surprisingly little welding performed on medium carbon steel. Practically all of the steel that is used for welding contains less than 0.35% carbon. The medium carbon steels with 0.35 to 0.50% carbon are rarely welded because the welds, if made under the customary conditions for low carbon steels, are unusually hard and lack ductility; that is, the welds are brittle and often crack.

The scientific explanations of the difficulty of producing ductile welds in medium carbon steel has been sought by R. W. Emerson, who, while finding the explanation, has also discovered methods to overcome the practical difficulties. The scientific explanation relates to the fact that the higher the carbon content of a steel, the slower it must be cooled from welding temperatures to prevent hardening. Furthermore, the hardness attained increases with the carbon contest, but the main factor is the cooling rate at temperatures below about 700 deg. C., because it governs whether or not the crystals of steel at a red heat have time to change during cooling to a soft form instead of a hard brittle structure.

Emerson measured the temperature of steel in the immediate vicinity of the weld during the entire process of welding, and found that the cooling rate when the steel has just lost its red color after depositing a customary weld exceeds the rate known to produce soft structures in steel. In order to slow down the rate of cooling and thus secure soft instead of hard welds, either of two welding factors may be altered. First, the speed of welding may be decreased; second, the steel itself may be kept at an elevated temperature (300 deg. C.) during welding. The latter procedure is known as preheating. Reheating the finished weld was found to be helpful in producing ductility.

*Research Engineer, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Welding of Silicon Bronzes

By E. S. BUNN, J. R. HUNTER, W. G. SEIDLITZ*

★ Silicon bronze is an alloy that is being used to a surprising extent for tanks to withstand high pressure gases and liquids. The silicon bronzes generally contain 1 to 3% silicon. With the long carbon arc welding process silicon bronze up to ⅝ in. thick is readily welded into pressure-tight vessels that withstand severe tests and equally severe service.

In the carbon arc process described by Mr. Bunn, Hunter, and Seidlitz an electric arc (25-45 volts, 100-280 amp.) is struck between the edges to be joined and a pencil pointed carbon rod 3/16 to ½ in. diameter. The heat of the arc melts the edges of the bronze plates as well as the end of a silicon bronze rod that is held in the arc by the operator to fill the gap between the plates. Flux is used to rid the weld of the silica (oxide of silicon) that forms on the molten metal. It is curious that, although the flux is 25% borax, the ordinary grocery store variety of borax will not do, because it contains 47% water. Absolutely dry fused borax is essential for the flux, which also contains manganese boride and other materials and is mixed to a paste with alcohol.

The success of the weld depends largely on the manipulation of the carbon electrode, that is, on the human element. The welder must maintain a long arc (about twice as long as the filler rod is thick) and must keep it directed on the edges of the plate where the metal is thick, rather than on the center of the weld where the metal is molten and readily sags. The welder therefore whips his carbon from one edge of the weld to the other without overheating the middle of the weld. Since it is practically impossible to prevent sagging of plate less than 3/16 in. thick, a bronze strip is clamped below the weld to catch the plastic or liquid metal and chill it.

The filler rod is deposited in the weld at the rate of 7 to 12 ft. per minute for a single bead. Five beads constitute a weld in silicon bronze ½ in. thick. When the weld is completed it may be peened, although peening is time-consuming. The completed weld has remarkably high strength (55,000 psi.) and ductility.

*Mr. Bunn is assistant director of research; Mr. Hunter is welding engineer; Mr. Seidlitz is technical adviser; all of them with Revere Copper and Brass Inc.

All-Welded Lake Freighters

By R. W. BRENDLE*

★ A great deal more freight than is generally realized reaches the Atlantic Coast ports from Detroit by boat, through Lake Erie and the New York Barge Canal. These boats are in no sense barges. They are self propelled diesel vessels 300 ft. long, 43 ft. beam, 12 ft. draft, of 1946 tons gross weight. Two of the most recent vessels to enter this service are arc welded throughout.

The vessels were constructed as much as possible under the shop roof. After the keels were laid the shop-fabricated parts were butt welded in place, using covered electrodes. Erection was kept about one hatch space (two days) ahead of the finish welding. In general, the welding was started at the center of the ship working outward to port and starboard, and to fore and aft in order to control distortion. Each vessel was 89 days on the building ways.

The welded vessels, which were launched sideways in characteristic Great Lakes fashion, are able to carry 15% more cargo than their older, riveted sister ships. Despite lack of previous welding experience there was no difference in cost of construction between the welded and riveted vessels. R. W. Brendle, the welding foreman, also observed that there was a notable absence of vibration on the welded ships and that repairs after a minor grounding simply involved hammering out dents, there being no riveted plates to replace.

*Welding Foreman, Great Lakes Engineering Works.

Progress in Copper Welding

By I. T. HOOK and C. E. SWIFT*

★ The welding of copper by fusion has been hindered first and foremost in the past by the high rate at which copper transmits heat. Both welding processes that have survived the test of time involve highly concentrated sources of heat: the oxy-acetylene flame and the long carbon arc. A second difficulty has been the presence in the copper of 0.03 to 0.07% oxygen, which was sufficient to cause a fatal weakness in the welded copper a few thousands of an inch from the line of fusion. The third problem has been the development of a rod to produce strong, ductile weld metal.

In their research the authors have accepted the two more or less standard welding processes, and have worked out the solution of the oxygen and rod problems. Critical tests made under severe conditions on copper plates ¼ or ⅜ in. thick showed that it is better to use copper absolutely free from oxygen, known as silicon-deoxidized copper, in preference to copper containing oxygen. Of the welding rods that were tested, the rod composed of copper containing 3% silicon and 1% manganese yielded welds with the highest strength and ductility both in arc or oxy-acetylene welding. A rod containing 10% tin and 0.3% phosphorus was equally satisfactory for arc welding, but unsatisfactory for the oxy-acetylene process. All in all, the fusion welding of commercially pure copper has been put on a sound basis and the copper welder can approach his work with assurance of success.

*Research engineer and welding engineer, respectively of The American Brass Co.

Machine Flame Cutting

By O. C. VOSS*

★ Like most industrial processes flame cutting, which is the method of severing steel by means of an oxygen jet burning its way through the metal has become highly mechanized. The flame from a cutting torch consists of the oxy-acetylene preheating flame to bring the steel to the ignition temperature surrounding the jet of cutting oxygen in which the steel burns to a fluid mixture of oxide with a little metal. The mixture, called slag, is blown clear of the cut by reason of the oxygen pressure. The path of the oxygen jet represents the cut.

Instead of guiding the torch by hand to produce the multiplicity of flame cut shapes that are in common use, O. C. Voss employs one of a number of types of machines consisting of a carriage to carry the torch and a track of the desired contour. The machine traverses the track and cuts the steel, which may be ⅛ to 14 in. thick.

Two technicians are involved: the track designer and the torch operator. The track designer is the real key to the problem of producing cut shapes that can be assembled into a welded structure without additional machining, tolerances being held to an average of ¼ in. He must produce templates from blueprints, and must be thoroughly acquainted with welding technique and shrinkage. The torch operator must be as familiar with the adjustment of his torch as the infantryman with his rifle. Cleanliness, and adjustment are critical factors. Both designer and operator are the background for the successful functioning of the flame-cutting machine.

*Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Efficiency in Oxygen Cutting

By G. M. DEMING*

★ To the ever-widening circle of users of oxygen cutting this encyclopedic treatise by Mr. Deming will be particularly valuable. In ship-building, building construction, and in fact, in all steel fabricating plants oxygen cutting machines are cutting steel of greater thicknesses and at greater speeds than had hitherto been dreamed of. Yet the process is extremely simple. The surface of the steel is heated to a red heat the burning temperature, by a number of tiny flames in the center of which is a jet of pure oxygen that burns the preheated steel. When the cutting torch is attached to a motor-actuated carriage it becomes an oxygen cutting machine capable of making long, complicated cuts with practically no supervision.

In order to determine whether he is making a correct oxygen cut, the operator examines the cut surface. The jet leaves its fingerprint, as it were, on the cut in the form of regularly spaced ridges that are barely perceptible. The curvature of these ridges is known as the drag and is the most basic requirement of a cut. All adjustments of torch motor, and oxygen pressure are made on the basis of a measurement of drag. Another important requirement is oxygen purity, which must be 99.5% or better. The usual preheating fuel is acetylene, although illuminating gas, propane, and other fuels may be substituted.

Besides dealing fully with the operation of cutting machines and the economic aspects, Mr. Deming gives the prospective user of oxygen cutting a host of invaluable "tips" on the purchase and care of equipment. Among other things, the purchaser should make certain that the diameter of the smallest restriction in the cutting oxygen passages of a torch is at least

*Air Reduction Sales Co.

20% larger than the cutting orifice of the largest tip to be used. The purchaser should be aware also that there are three-hose torches possessing many conveniences of adjustment over the more customary two-hose torches.

Arc Welding Road Equipment

By E. E. ISGREN*

★ The super-highways we have today depended for their rapid, low-cost construction on large tractor-operated road building equipment operated under conditions of severe punishment. The rugged construction required in road equipment is attained by the use of alloy steel and arc welding. Welding is essential not only because welded construction is tough, but because welding, in contrast to other methods of fabrication, permits the box beam to be made simply and economically.

Throughout the entire construction of a scraper, the commonest type of road machine, the box type of beam is used, as E. E. Isgren describes in detail. The beams, long and short, straight and curved, are made on a production basis in lengths of 30 ft. from flame-cut angles and plates. These beams are later cut to the length desired for a given sub-assembly of the scraper. Welding is done on the beams while they are moving on conveyors. The sub-assemblies, on the other hand, are welded in fixed position to maintain exact dimensions and to facilitate the fitting of members. The sub-assemblies after completion are moved to the final assembly line where they are mounted on the body by means of pins and bolts. In this way all structures are one solid unit unified by arc welding. Yet, upon the removal of a few pins or bolts, any one complete structure of the unit can easily be removed for repair or replacement.

*Plant Superintendent, R. G. Le Tourneau, Inc., Peoria, Ill.

Truss Type Railroad Car

By A. M. UNGER*

★ The railway passenger car is always associated with high speed, but with some vibration and shock to which all of us rapidly get accustomed. Speed and shock involve severe stresses in the framework of the car, which must be amply strong to meet the high standards of safety insisted upon by the railroads. It is significant of the role now played by welding in industry that the modern railway passenger car is of welded construction.

The basic principles involved in the construction of railway cars and bridges are remarkably similar, and, as A. M. Unger shows, the trend has been away from the girder type of construction in which the entire side sheeting of the car must withstand considerable stress. Instead, the truss principle is being adopted, primarily to save weight, the truss being a lattice-work of strong welded members over which a very thin sheet of metal is placed to keep out the weather.

Experimental welded side frames for cars designed on the truss principle were made of alloy steel and tested both under steady loads and under falling weights. In both steady load and impact tests the experimental frame withstood ample overloads without failure. When, under extraordinary overload (over 200%), the frame did fail, there was no sudden cracking of members, but simply a ductile twisting and bending of the main members.

*Welding Engineer, Pullman-Standard Car Mfg. Co., Chicago, Ill.

Tools, Jigs, and Fixtures

By M. S. EVANS*

★ It is quite easy for the engineer to design complicated mechanical equipment to be welded. It is quite another matter to weld according to the engineering design so that the finished product, besides being an accurate reproduction, is economical as well. "Can the well-trained, industrious welder," asks M. E. Evans, "be expected to produce good workmanship and meet estimated costs, if he is handicapped by improperly prepared and assembled material?"

The answer is, of course, in the negative and Mr. Evans describes jigs and fixtures, which are devices for assembling material by means of welding. In the construction of jigs and fixtures the welder must be allowed ample room to manipulate his electrode, yet the construction must be sufficiently rigid to withstand distortions created by the heat of welding. Despite the importance of correct design of jigs and fixtures, the necessity for providing the welder with accurately cut material for the welded assembly is even more pressing. A poor fit wastes time and welding rods. Consequently, conscientious shop preparation and appropriate tools together with jigs and fixtures of intelligent design have a very decided influence on workmanship, output, and costs in production arc welding.

*Plant Engineer, American Car and Foundry Co.

Welded Joints in Carbon-Molybdenum Piping

By R. W. CLARK*

★ The steam power stations that supply most of our electricity use pipes to transfer the steam from boiler to turbine. The turbine transforms the energy in the steam to electricity through the medium of an electric generator. The critical part of the power system has often been the steam pipes, which are about 8 in. diameter, ½ in. thick and sometimes operate at a dull red heat under high pressure. The steel favored by R. W. Clark for steam power piping is a low carbon steel containing ½% molybdenum, an element well known by steel experts. Experience has shown that the welded joint is the best for these steam pipes just as welding is best for the boiler itself.

Two problems must be faced in using carbon-molybdenum steel for welded piping. First, the welding process must yield sound welds without blow holes. This problem has been solved with comparative ease by the use of covered arc welding electrodes containing ½% molybdenum, ⅛ or 5/32 in. diameter, together with any of four, well-known types of welding grooves. General chipping of beads and craters is not necessary. R. W. Clark found that the recording voltmeter has no value for detecting defective welds.

The second problem is the avoidance of cracks. One of the best preventives of cracks has been preheating. The pipe to be welded is encircled by ring gas burners which heat the pipe in the vicinity of the welding grooves to a temperature of 500 deg. F. For further safety under severe conditions the weld may be relieved of shrinkage stresses by being reheated locally to 1200 deg. F. Tests made by R. W. Clark proved that the reheating actually removed these shrinkage stresses almost entirely. The resulting welded joints had excellent strength and ductility and were obviously all that could be desired for power steam piping.

*With General Electric Co.

Welding of Small Sub-Assemblies

By E. J. DE WITT*

★ The first endeavor of the engineer faced with the problem of designing and constructing a complicated machine, such as a pipe bender, is to break down the machine into its component parts. Instead of a complex mechanism, he will then have a number of comparatively simple units which can be analyzed to a large extent independently of the rest of the machine. He finds as he delves into his "art," that practically anything can be built of welded steel.

The welding of the simple units that go to make a pipe bender is described by E. J. DeWitt, who has found through long experience that pipe benders can be better welded than built by any other process. The high-strength steels that must be used in pipe benders are tested for their resistance to cracking and excessive hardening. A hard weld often cannot be permitted because it is unmachinable. Under some circumstances the weld may be peened while it is still hot.

Suitable steels for all parts having been selected, the engineer evolves a welding procedure that is as simple as possible in itself and introduces no difficulties in the finishing of the welded unit. The accessibility of the weld to the welder, the spacing of welds to compensate for warping, and the machining of the parts at different stages during welding are among the numerous expedients available to the welding designer, which are often denied to designers using other methods of fabrication. The welding designer is at his best in designing the intricate units now demanded by most fully automatic machinery.

*Chief Engineer, Wallace Supplies Mfg. Co., Chicago.

Welding of Unfired Pressure Vessels

By R. M. WALLACE*

★ In the past few years a new welding process has been developed and applied in the manufacture of boilers and tanks to withstand high pressures, and in shipbuilding. The process, known as Unionmelt, consists in melting a bare rod of steel into the small open space provided between the two plates to be welded. The gap between the plates is filled with a powdered mineral which acts as flux and also as a source of heat derived from the electric current that is made to flow from rod to the plates through the powder. The gap is backed up by a copper strip that prevents the powder and molten metal from draining away through the gap.

The human element is almost entirely eliminated from the automatic Unionmelt process. The rod is held vertically above the gap between the plates. As the rod melts, some of the flux also melts and protects the molten metal so that the weld contains practically no nitrogen. The rod is moved along the plates through the flux and completes the weld in a single pass. In butt welding mild steel plates 1⅛ in. thick by the Unionmelt process, the bare rod is 5/16-in. diameter and moves at a speed of 9⅜ in. per min., the current and voltage being 1320 amp. and 39 volts, respectively. The current and speed are much higher than those employed in arc welding.

The process has been most successful in welding boiler drums 14 in. to 7 ft. diameter, ¼ to 1½ in. thick. The welds have essentially the same composition, strength, and ductility as unwelded base metal, even in stainless 18-8 steel and in steel containing 4 to 6% chromium. The latter steel is preheated for welding. If mild steel is to be welded by the process it should preferably be of slightly higher quality with respect to slag and sulfide inclusions than ordinary boiler plate. Several hundred high-pressure tanks and drums have been constructed by the Unionmelt process and have passed the severest inspection and tests, it is stated.

*With Griscom-Russell Co.

Welding of Large Steel Yachts

By E. M. WHITEHOUSE*

★ The only floating post office in the world is a welded vessel. It delivers mail to ships underway passing through the Detroit River. Fireboats, tugs, and government cutters are among other medium-size craft now being welded.

When a government, firm, or an individual plans to purchase a boat or yacht, the boat builder's advise about the best method of construction is often sought. Mr. Whitehouse says, "We hope we never have another riveted job, although we are fully equipped for riveting." The factors in favor of welding are weight and labor. The welded vessel is lighter than its riveted sister ship and can carry more, faster. Whole divisions of labor, such as drilling plates for riveting, fitting, pattern work, and caulking, are eliminated by welding.

Moreover, the plates must be more accurately shaped for riveting than for welding. The plates must be bumped to shape so that they fit neatly into the hull. Nevertheless, the welded plates, besides being as sightly as the old riveted construction, are free from the leakage that often developed at riveted seam straps. Mr. Whitehouse describes an all-welded steel yacht, 115 ft. long, air conditioned and acoustically treated, with aluminum alloy superstructure that weighed only 92 tons instead of 125 tons which would have been the weight of a riveted yacht of the same design. As a result the cost of construction was decreased, the vessel was more comfortable, and there was an increase of speed of 4 miles per hour with the same horsepower.

*With Defoe Boat and Motor Works, Bay City, Mich.

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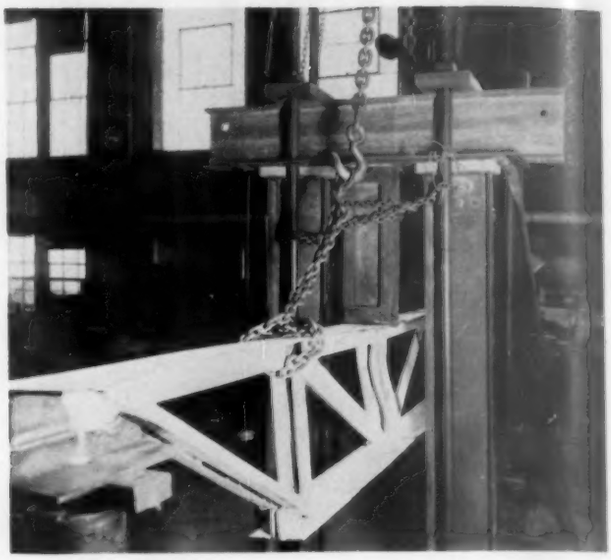
Rubber-Lined Welded Pipe for Eastern Chemical Plant

★ Over 100 ft. of special rubber-lined pipe ranging from 42 in. to 72 in. in diameter will be installed in a large plant located on the Atlantic seaboard which is engaged in the production of chemicals obtained from ocean water. The pipe will be used to handle chlorinated and acidified water at 30 deg., and was lined with a 3/16-in. thick Vulcalock hard rubber lining by The B. F. Goodrich Co., Akron, Ohio, as a protection against corrosion.

Special "Y" branch 72 in. x 42 in. x 48 in. which was one of several complicated welded fittings rubber-lined for chemical service.



Welded steel truss tested to destruction at research testing laboratory, Ohio State University, Columbus, Ohio. There was no evidence of failure at welded joints, even though truss buckled considerably.

Sixth of a series of practical articles on

Technique of Arc Welding

★ How to make vertical butt welds without undercutting the plate—Outside and inside corner welds—Best to make "hot" laps when restarting

By ROY OWENS
Welding Instructor, Electro-Motive Corp., LaGrange, Ill.

FIGURE 32 shows a butt weld made vertically. This motion is recommended for butt joints that are not vee'd out. The electrode is slanted approximately 5 deg. below horizontal to melt down the parent metal and to cause the molten metal to flow down out of the arc into the crater and solidify. This will also allow the arc to burn into the parent metals to a greater depth of penetration. In restarting the bead, caution should be taken to see that the crater is brought to a molten stage before continuing the weld. Penetration equal to the diameter of the electrode can be obtained with this motion if proper heat and technique is used.

Figure 34 shows a side view of the joint in Fig. 32, the electrode first being held as indicated in position *A* when arc is struck at one side of crater. The electrode is then carried across lower part of crater and as the crater comes to a molten pool, the electrode is brought down to position *B*. This procedure will cause the arc to penetrate into the parent metal and the crater will be kept at a molten stage, thus insuring that good fusion will be obtained.

An all-position electrode will give best results for good penetration and with this motion the operator should have no difficulty with undercutting as the motion describes an oval shape. The electrode will be at the highest point of the stroke at the center of the weld and will then start downward to the end of the stroke. Some of the molten metal will flow down to the end of the stroke being deposited there as the stroke starts back, thus preventing the undercut. This motion is recommended for welds from ¼ in. to ¾ in. across the face. On larger welds of this type the operator may find it difficult to keep the crater at a molten stage, because the arc cannot keep such a large area heated and when the arc is at one side of the weld, the other side will solidify and will have to be remelted before it can be fused to the next layer of metal.

A weld of normal size when made with this motion will require a minimum amount of time. There is no lost

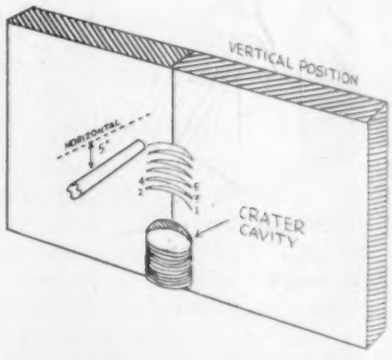


Fig. 32—How to make vertical butt weld where plates are not vee'd.

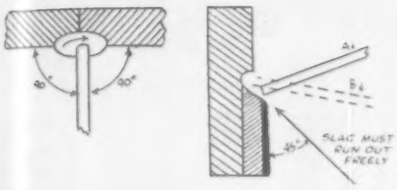


Fig. 33—Top view indicating position of electrode and elliptical motion while welding

Fig. 34—Side view of vertical joint showing electrode position in restriking arc (A) and when welding (B).

motion in this type of welding. If the operator travels too slowly, one of two things will very likely happen: (1) The metal may become too hot and spill over the side; (2) Holes may be burned through. Since this is a hot weld, the operator cannot make it as neat appearing as is sometimes desired. For this reason the motion is not used by more than about 25% of all welders. No trouble will be encountered with slag inclusions if the operator keeps the metal building up at about a 45 deg. angle (as indicated by arrow). This will allow the slag to flow out of the crater before it solidifies.

Figure 33 shows a top view of Fig. 32 indicating the electrode position and how the arc is carried into the metal on half of the stroke and out again to the finish of the stroke. This sketch indicates the electrode travel as seen from the top edge of the plates.

Figure 35 is the same type of joint but a different motion is used. This is a half circle motion and although I do not recommend it for this type of joint, it will be found very good on vee'd joints and outside corner joints, as shown in Fig. 36, where there is a large filling. In this motion, the electrode starting from (1) is carried downward to the center of the weld and then along the upward curve to (2). The motion then retraces itself down and across to (3) and continues in zig-zag fashion. As the arc is on a downward curve from the side until it reaches the center of the crater it will cause the molten metal to flow away from the edges to the center or lowest point, thus building out a high bead and probably leaving undercut edges.

For this reason the arc is carried up along the side of the crater to fill up any undercut that may have been made by the previous stroke. Also, this weld will not have quite as good penetration as the motion shown in Fig. 32, but it will be much neater in appearance. The reason this weld can be made neater in appearance is that it is made with just enough current so that when the arc is at one side of the weld, the other side will solidify before the arc is brought back across the crater. The operator will have better control of the molten pool if it is kept small. The electrode should be held at about 90 deg. from the vertical plate. An all-position type of electrode for vertical and overhead welding should be used.

Figure 36 shows a weld on an outside corner with the plates set corner to corner, making a 90 deg. groove to be filled in. This will require a good sized bead and the motion shown in Fig. 35 will give best results for this type of set up because the filling is greater at center of weld than at sides. However, vee'd butt welds, wherever

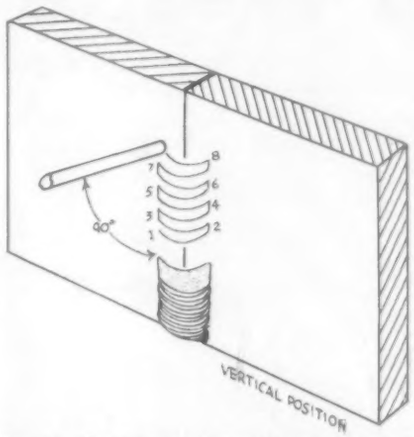


Fig. 35—Another type of motion used for vertical butt joint, although not recommended for most work.

possible, should have a stringer weld put in first to eliminate the chances of non-fusion in the bottom of the vee. The motion of Fig. 35 concentrates the heat along the sides of the weld in the heavier section and the bottom of the vee may be skipped on the cross stroke.

Figure 37 shows a fillet weld in an inside corner made vertically with the same motion as shown in Fig. 32. This motion is exceptionally good for welds up to ¾ in. It is a one-pass weld with a slightly concave center. The weld will have great tensile strength and the penetration will exceed the average. A short arc must be maintained when this weld is being made. When properly executed there will be a burned out groove above the molten pool. This cavity will indicate the amount of penetration obtained.

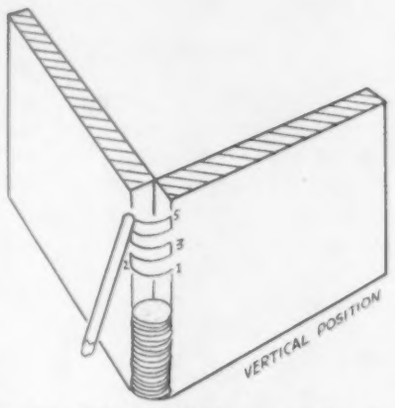


Fig. 36—Making an outside corner weld, using same motion as in Fig. 35.

On jobs that must be water tight when tested it has been my experience that 50% of the leaks occur at laps in the welds, where the weld had been stopped and then restarted. This is known as a "cold" lap and is caused by striking the arc in the crater and depositing filler metal before parent metal has reached the fusion point. The filler metal will adhere to the parent metal and appear to be fused. It is a good policy if the operator will form the habit of making "hot" laps on all welds to prevent this situation from occurring. To make a "hot" lap, the arc should be struck at one side of the heel of old crater and carried slowly across the crater and then continued upward into the parent metal. By the time the arc is carried across the old crater, the parent metals will be at a molten stage.

A "hot" weld is a weld that is kept at a molten stage the full width of bead during the weld. This type should be used wherever possible. A "cold" weld is a weld that is not kept at a molten stage the full width of the bead. Just enough heat is used to keep a small molten pool of metal at the end of electrode and is carried from one side of the bead to the other by the arc.

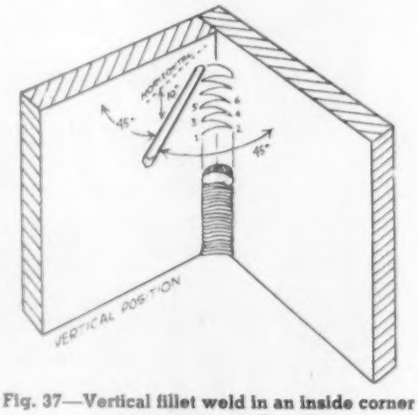


Fig. 37—Vertical fillet weld in an inside corner —same motion as Fig. 32.

Unique hull construction of Dolomite IV. Fabricated from 18-in. rolled steel channels butted together flange to flange and welded (½ in. penetration) both inside and out.

Unique welded hull construction used on new

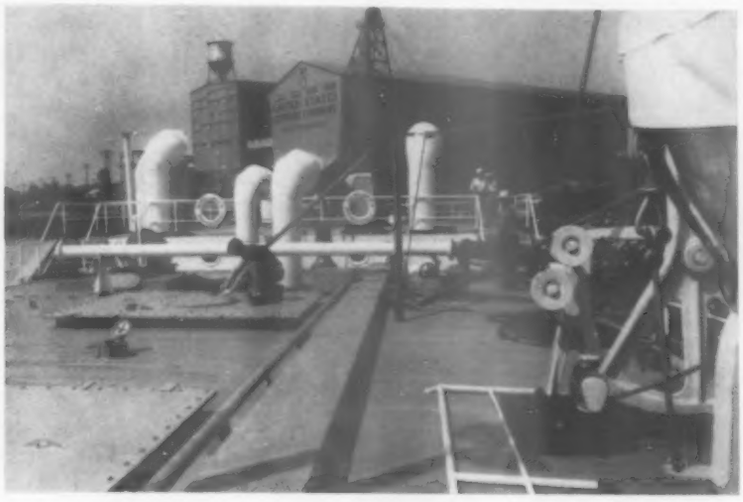
4000-Ton Welded Tanker

★ Five storage tanks are lined with pure nickel sheet, 16 gauge. Greater flexibility in obtaining cargo is an important feature of nickel-lined storage tanks

WHAT IS SAID TO BE the largest welded vessel on the Great Lakes completed her maiden trip from Oswego, N. Y., to East Chicago, Ind., recently with 1,200,000 gallons of kerosene. This boat, the Dolomite IV, is a 4,000-ton welded tanker, built entirely of rolled steel channels. Over 40 miles of welded seams were required to build this boat. An outstanding feature of the Dolomite IV is the nickel lining of the five storage tanks for handling oil and other bulky commodities. Each of these tanks has a capacity of 125,000 gallons. These tanks are placed end to end longitudinally and they are centrally located between the wing tanks at each side. Each tank measures 36 ft. long by 24 ft. wide and 19 ft. high.

By using a nickel lining the tanks can be rapidly cleaned and the vessel can change cargo from oil to grain or caustic soda, whatever is most profitable. It is said that this is the first time that pure nickel lining has been used in the holds of such a large tanker. In checking over the data sheets on this job we find that 60,600 lbs. of pure nickel sheets and strips were used for tank lining. A total of 1,200 lbs. of nickel metallic arc welding electrodes were used in butt welding the seams of the nickel sheets. Rolled nickel sheets 4 ft. by 8 ft. (16 gauge) were spot welded to the carbon steel tank plates by using a portable-type spot welding unit. This spot welding was largely for the purpose of holding the nickel sheets in position for the arc welding of the seams. No. 135 Inco welding electrodes, ⅛-in. diameter, were used in welding the

Over 40 miles of welded seams were involved in fabricating this new tanker. Photo, courtesy of International Nickel Co., New York City.



View of welded deck, looking aft. A member of the crew is tightening a man-hole cover above cargo tank.

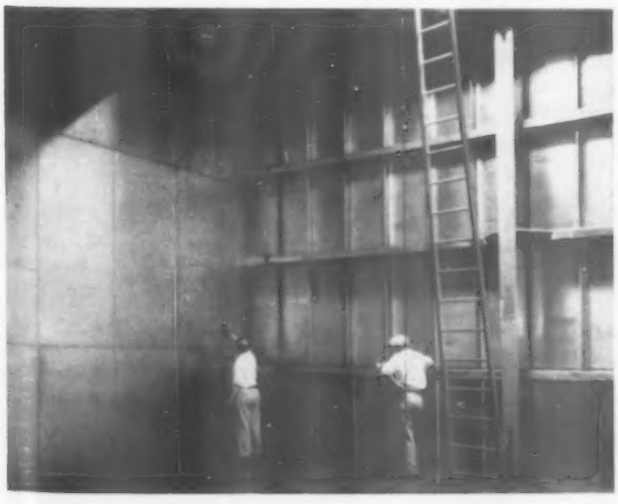
seams, the nickel sheets being spaced 3/16 in. Before welding was started on the tank lining, specimen welds were made to determine how much "iron pick-up" occurred in making the welded joints between the nickel sheets. Tests made in a chemical laboratory indicated not over 1½% "iron pick-up" in the welded joint. Most of the welding had to be done in the vertical position.

The hull was fabricated entirely by arc welding from rolled steel channels 18 in. wide, ½ in. web. The channels were butted against each other, flange to flange, and arc welded together both inside and out.

Automatic arc welding by the "Electronic Tornado" process, using Lincoln tractor type welders, was employed in fusing the main seams of the hull. A current of roughly 900 amp. was used on the carbon arc heads and the speed of welding, making a ½-in. throat on butt welds without scarfing, was 35 ft. per hour. This process was approved by Lloyds. Other welding was done by the manual process. Some 90,000 lbs. of Lincoln "Fleetweld" electrodes were used on the hull.

An interesting feature of the construction of the boat is that it is literally a boat which has never been launched, because it was built in an unused lock of the Erie Canal near Rochester, N. Y. The boat was floated by siphoning water over the lock gates. After the water had reached the proper level the gates were opened and the boat passed into the canal on its way to Lake Ontario. The boat was built by its owners, the Dolomite Marine Corp. of Rochester, N. Y., at a cost of about $550,000. Use of a welded construction made it possible to complete the craft in 6 months.

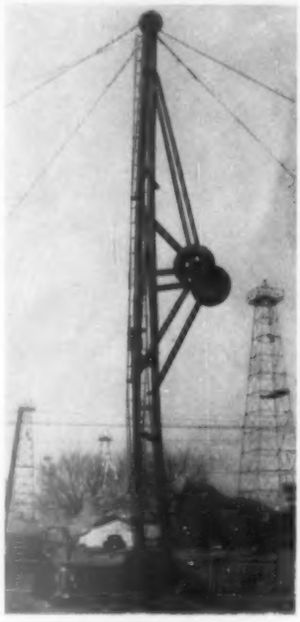
The craft is 300 ft. long with a beam of 43 ft. 4 in. After the close of Fall navigation on the Great Lakes she will haul caustic soda or lye and other corrosive cargoes between Gulf of Mexico ports and Norfolk, Va.



Inside one of the nickel-lined storage tanks. The 16 gauge nickel sheets were spot welded to the tank plates to position them for arc welding of the seams.

All-Welded A-Frame For Well Servicing

★ An ingenious combination of trailer and A-frame for servicing oil wells is in use in the East Texas oil field. The frame itself measures 42 ft. in length, with a spread at the base of 7 ft. Cross braces are welded at intervals, with the steel blocks carrying the bearings for the twin sheaves at the top carried in expanded bushings welded to the upper ends of the pipe forming the stands .



Forty-foot mast, all-welded, speeds servicing of oil wells and permits quick shifts between locations.

Transportation of this unit between wells is facilitated by welding an axle midway of the frame, with suitable braces to stiffen the attachment and brace the frame against flexing and vibration on rough roads. This bracing for the axle is so planned and supplied as to serve also as stiffener members for the A-frame when in service at the well.

On the road, the wide base of the A-frame is attached to a heavy truck, or carried thereon, while the two-wheel truck follows as does any other trailer. The sheave end is carried clear of all road obstacles. Welding the axle and supports to the frame as an integral part of the structure is estimated by the well-servicing contractor as saving him the service of two men when making a move, and cutting the time required by at least two hours.

News of the Industry

AMERICAN CHAIN & CABLE CO.
METAL SHOW EXHIBIT

Information regarding the exhibit of the Page Steel & Wire Division, American Chain & Cable Co., Monessen, Pa., was received too late to be included in the September Metal Show issue of *The Welding Engineer*. This company will exhibit, in Booth C-515, a complete line of coated electrodes and stainless steel electrodes.

The exhibit of the Campbell Division, American Chain & Cable Co., will feature the following cutting machines:

No. 213 Abrasive Cutting Machine with following features: (1) New coolant system with 4 distinct improvements; (2) Micrometer stop bar for quick micrometer adjustment; (3) New type bar holder and clamps for long or short stop; (4) Moisture and dustproof spindle closure which protects spindle bearing; (5) Protective wheel guard which eliminates coolant splash and protects operator.

Campbell Cutting Machine for Flat Stock.

No. 401 Cutamatic Abrasive Cutting Machine.

In attendance for Page Steel & Wire Division will be W. H. (BILL) BLEECKER, division manager, E. J. (TIM) FLOOD, district manager, Chicago; FRED H. JONES, district manager, Pittsburgh; and JIM SKINNER, welding demonstrator, Monessen, Pa.

The Campbell Division of American Chain & Cable Co. will be represented by R. J. SOUTHWELL, sales manager, and GRANT CASSERLY.

» «

SPECIAL COURSE IN WELDING ENGINEERING—Rensselaer Polytechnic Institute, Troy, N. Y., has planned an intensive course in welding engineering for engineers, who have completed courses leading to degrees in engineering or allied sciences. This course is also available to men whose responsibility in industry has given them experience equivalent to an engineering course.

The intensive course will be of four weeks duration, with the option of an additional two weeks of experimental work of special interest to the individual student. Time will be devoted to metallurgy theory, theory of welding and structural design. Laboratory experience will include heat treatment, microscopic examination, welding, cutting, and physical, magnetographic and radiographic testing. There will be regular library assignments, discussion groups and visits to nearby plants. The optional two weeks will be available for more laboratory experience in particular branches, such as the weldability of a certain type of steel, spot welding, or any other phase which may have a special appeal.

This special course will begin Wednesday, November 2, 1938. Tuition fee will be $100 for the basic four weeks course, plus an additional $25 for the optional two weeks course. All communications with regard to this course should be addressed to Professor Wendell F. Hess, Department of Metallurgical Engineering, Rensselaer Polytechnic Institute, Troy, New York.

» «

EYE PROTECTION—At the annual meeting of the National Safety Council held at the Stevens Hotel, Chicago, the subject of eye protection was discussed by three speakers on Thursday afternoon, October 13. "Goggles for Protection Against Radiant Energy" was the subject of a talk by G. E. SANFORD, General Electric Co., Schenectady, N. Y. "Goggles for Protection Against Flying Missiles" was the subject of a talk by HARRY GUILBERT, Director of the Bureau of Safety and Compensation, The Pullman Co., Chicago. "Goggles for Protection Against Corrosive Liquid Splashes" was discussed by P. V. TILDEN, assistant manager, E. I. du Pont de Nemours & Co., Wilmington, Del.

» «

H. R. MOULTON, assistant research director of the AMERICAN OPTICAL CO., Southbridge, Mass., has developed a 5-point program to improve industrial efficiency. Adoption of the program may increase efficiency of workers 25 per cent, resulting in the saving of millions of dollars annually. The program brings sharply into focus a new conception of management responsibility toward workers.

Basically an eye protection program, the plan also directly promotes general health. As outlined by Mr. Moulton, the program calls for:

1. Annual eye examinations to detect eye defects and vitamin A deficiency, now recognized as potent factors reducing industrial efficiency. Mr. Moulton referred to recent experiments conducted on color matching inspectors whose production was increased more than 75 per cent by feeding them concentrated vitamin A capsules daily.

2. Adequate safety programs, calling for the wearing of safety goggles, safety helmets, safety clothing, dust and gas respirators. Modern methods should also be used to eliminate dust from work-rooms. Such safety programs, Mr. Moulton stated, will protect workers from industrial accidents and silicosis, a deadly lung disease.

3. Ventilating systems to remove impure air and gases from work-rooms, bring in pure air, and regulate temperatures. Impure air and gases, Mr. Moulton explained, may be absorbed by moisture in eyes, act as a chemical irritant, and produce conjunctivitis (irritation of eye-lids) or even worse eye troubles.

4. Lighting systems to provide proper illumination, neither too bright nor too dim, for specific work. Eye strain is thereby avoided.

5. Setting up of several relaxation periods during the working day to recoup lost visual energy and decrease fatigue.

LEGAL STATUS OF LEAKY RIVETS—Masters of vessels and their owners are liable for pollution of navigable coastal waters arising from rivet leakage, according to a decision of the Fifth U. S. circuit court of appeals in which a fine imposed on Captain S. B. Hegglund, of the motor-tanker Bidwell, was confirmed. The ship's master had been fined $500 in the Federal district court for Western Louisiana on conviction on a charge of polluting the Calcasieu river. The Magnolia Petroleum Corp. was an intervenor in the case.

In affirming the lower court, the appeals decision held the statutory requirements of the Oil Pollution Act of 1924 to be constitutional, and that leakage at the rivets by the vessel did not constitute unavoidable accident within the meaning of the statute. Said the court in part: "We think that a correct construction of the statute is that leaks from rivets of the kind testified to in this case are not unavoidable accidents. We think the statute absolutely forbids the prohibited discharge in coastal waters, and due care is not a defense."

» «

DRAVO DUPLICATES WELD AWARDS—The general interest of industrial organization in the awards of the James F. Lincoln Arc Welding Foundation is indicated by the action of the Board of Directors of the DRAVO CORP., Pittsburgh, Pa., which has awarded duplicate prize payments received by the four winners in the organization. Those who have received company bonuses as well as their prizes are GEORGE F. WOLFE, chairman of the Dravo welding committee, engineering works division; J. F. SMITH, welding engineer; C. P. STREITHOFF, structural engineer; and GILBERT H. ATWOOD, assistant chief draftsman.

A.W.S. Activities

LOS ANGELES SECTION, A.W.S.—"Steel Castings and Welded Structures" was the subject of a talk by E. C. HUMMEL, general manager of Utility Electric Steel Co., Los Angeles, at the September 15 meeting of the Section. He presented an illustrated lecture and discussion depicting the relationship between welding and foundry practices. Among the subjects he covered were: Repair of castings by welding; use of the oxy-acetylene torch in the foundry; composite cast and welded structures, and all-cast vs. all-welded structures.

» «

CLEVELAND SECTION, A.W.S.—"Welding in the Steel Industry" was the subject of a talk by ROBERT E. KINKEAD, consulting engineer of Cleveland, Ohio, at the October 5 meeting of the Section, held at the Cleveland Club. This was the first regular monthly meeting of the Section for the 1938-39 season.

» «

SAN FRANCISCO SECTION, A.W.S.—The Section held its first meeting following the summer period in the auditorium of the Alameda High School, Central and Walnut Sts., in Alameda, Calif., September 23. Chairman N. F. WARD presided.

THE FLEXARC WELDER

Constant, stable arc assured by the Arc Watchman

No nuisance gadgets

Unlimited number of current steps. With proper arc length, voltage adjustment is automatic

Single pre-set current control

Westinghouse

"What does it mean — a welder without exciter, reactor, brush shifting devices or series field taps?"

"That's engineering language for nuisance gadgets."

"Is there a machine without those gadgets?"

"Sure is. It's the Flexarc—It's got the constant current job licked at last."

"How do they do it?"

"Made a generator especially for arc welding, with the Arc Watchman built in."

"What does that do?"

"Takes care of the voltage — for either light sheet gauge or heavy plate—all I need to do is hold the proper arc length for the job, and the Arc Watchman pours in the metal."

"Must be a sweet machine."

"Right you are—better try it."

WESTINGHOUSE ELECTRIC & MFG. COMPANY, EAST PITTSBURGH, PA.

J20648

WESTINGHOUSE FLEXARC WELDER

"Low Temperature Brazing," was the subject of the main feature of the evening, which consisted of both a practical demonstration and a technical discussion of the topic by representatives of Handy and Harman, New York City. Much interest was shown in this instructive demonstration which has been shown before various organizations in recent months.

» «

CHICAGO SECTION, A.W.S.—At the first monthly meeting of the current season, held September 16, ELMER ISGREN, superintendent of R. G. LeTourneau, Inc., Peoria, Ill., presented an interesting talk, illustrated with slides, relating to the manifold uses of welding in his Peoria plant. The meeting was held in the Auditorium of the Link-Belt Co., 300 W. Pershing Road, Chicago. A feature of Mr. Isgren's talk was the example he cited where welded fabrication was carried out in the shop before the drafting room could prepare plans. It was evident from his talk that R. G. LeTourneau is completely "welding minded." Many production tools in the shop have been built under Mr. Isgren's supervision, with the aid of the shop's welding equipment.

Personals

W. C. SWIFT has recently joined Compressed Industrial Gases, Inc., Chicago, as consulting engineer. Prior to his joining the staff of CIG, Mr. Swift had acted in the capacity of consulting engineer for the American Brass Co. for a number of years. Mr. Swift's knowledge of welding and cutting processes is quite broad due to his association with the welding and cutting industry more than 20 years. His services will be available as a consultant to those having welding and cutting problems.

Mr. Swift will continue to contribute articles on welding for publication in the welding and cutting industrial trade publications. His headquarters will be at the executive offices of Compressed Industrial Gases, Inc., 221 N. La Salle St., Chicago, Ill.

Future Meetings

October 17-21, 1938

National Metals Congress and Exposition, held in conjunction with American Welding Society, American Society for Metals, American Society of Mechanical Engineers, American Institute of Mining and Metallurgical Engineers, and The Wire Association. American Welding Society headquarters will be at the Book-Cadillac Hotel, Detroit, Mich.

October 24-27, 1938

American Mining Congress (Western Division)—Fifth Annual Metal Mining Convention and Exposition at the Ambassador Hotel, Los Angeles, Calif.

November 14-18, 1938

American Petroleum Institute, 50 W. 50th St., New York City.

Nineteenth annual meeting at the Stevens Hotel, Chicago, Ill.

November 28-30, 1938

American Institute of Electrical Engineers, 33 W. 39th St., New York City.

Southern District meeting at Miami, Fla.

December 1-2, 1938

Purdue University Annual Welding Conference will be held at Lafayette, Ind.

December 5-9, 1938

American Society of Mechanical Engineers, 29 W. 39th St., New York City.

Annual meeting in New York City.

December 5-10, 1938

National Exposition of Power and Mechanical Engineering will be held at Grand Central Palace, New York City.

Trade News

GENERAL ELECTRIC Co. received orders during the third quarter of 1938 amounting to $60,533,135, compared with $88,010,937 during the same quarter last year, a decrease of 31%. Orders received in the first and second quarters decreased 38% and 44%, respectively, from the corresponding periods last year. For the first nine months this year orders received amounted to $188,756,958, a decrease of 38% from the $305,276,556 received during the same period a year ago.

» «

WESTINGHOUSE "TIME CAPSULE"—On September 23, at the moment of the autumnal equinox, the Westinghouse "Time Capsule," carrying a compressed storehouse of information about today's civilization, began its 5,000-year journey into the future at the New York World's Fair grounds. A. W. ROBERTSON, chairman of the Westinghouse Co., gave the signal to lower the burnished Cupaloy capsule 50 ft. into the ground at the site of the Westinghouse building, a model of which was afterward unveiled.

To the solemn booming of a giant bell, the Capsule disappeared slowly into the earth. Workmen screwed down and sealed the cap, symbolically dispatching, for delivery in 5,000 years, the heaviest "letter" ever mailed. During the World's Fair, the Capsule may be on view through a periscope.

» «

BRIDGEPORT BRASS Co. announced the completion last month of a new rolling mill at Bridgeport, Conn., for the production of brass, copper and copper-base alloys for industrial and commercial use. Built at a cost of more than $4,500,000, the new plant, in which all rolling mill operations of the company will be located, marks the completion of the first major step in a long-range expansion and modernization program which was inaugurated early in 1937. It is estimated that the new mill will have a production capacity of over 6,000,000 lbs. of metal per month.

» «

ARCOS CORP., 401 No. Broad St., Philadelphia, Pa., has issued its illustrated Technical Bulletin No. 3. The bulletin contains new and previously unpublished information on the physical and metallurgical characteristics of stainless and special alloy welding. Bulletin No. 3 also includes a complete alloy welding manual for the engineer and the operator.

» «

AMERICAN IRON AND STEEL INSTITUTE has appointed BERT L. WOOD, formerly of the Carnegie-Illinois Steel Corp., as engineer in charge of a new program for promotion of the broader use of light steel construction in buildings. Mr. Wood's activities will be

The Improved "Round File" Gas Lighter

Most Economical

Unrivalled economy is provided by the many superior, exclusive design and construction features of the Improved "Round File" lighter.

An unusually large file area is provided — **approximately one square inch.** The file is of superior quality, hardened in our own factory. The spark metal is of large diameter and the patented cartridge holding the metal locks exactly into position, **permitting instant replacement.** The lighters are cadmium plated, rustproof.

Circulars and prices on request

SAFETY GAS LIGHTER CO. (Est. 1901) **LYNN, MASS.**

directed toward getting an equality of recognition for light steel products with other kinds of building materials.

The use of heavy structural steel has long been established in the construction field, but the use of light steels in residential and other building is a development of recent years and many building codes give them little or no recognition. At present the revision of building ordinances is in progress or is in contemplation in some 228 cities.

Among the products for which a parity of acceptance with other materials is to be sought are light structural shapes, structural sections formed from sheets and strip, sheet and strip steel for side walls, roofs, floors, doors, windows and lath; steel bars and steel joists, standard and special shapes for windows and doors, and tubular products. Tests of these and other steel materials will be sponsored by the Institute as a part of the program to promote the wider use of steel in building construction.

Foreign News

STANDARDIZE TESTS FOR WELDED STEAM PRESSURE VESSELS—It has been felt by the principal British engineering insurance offices that the construction of steam boilers and pressure vessels by metallic arc welding, which is now coming into widespread use in the United Kingdom, calls for the adoption of a definite standard of tests. With this object in view the Associated Offices' Technical Committee, representing the leading engineering insurance offices, has issued an authoritative "Schedule of examinations and tests during construction and upon completion of metallic arc welded drums and steam receivers." The issue of this specification was deferred until such time as, in the opinion of the companies, the necessary experimental work has been translated into a sound standard method of production.

Current Reviews

ARC WELDING MANUAL AND OPERATOR'S TRAINING COURSE—Hobart Brothers, Troy, Ohio, has just published in booklet form a series of practical lessons in arc welding as used in the Hobart Arc Welding School at Troy, Ohio. Formerly these lessons were only available to students attending the school, but in response to requests for this type of information, Hobart Brothers have prepared this instruction booklet. The book is priced at 50c, which it is said covers only the cost of production. Practical lessons in arc welding is a part of the larger Hobart book "Arc Welding and How to Use It," which is available at $1.50 per copy.

» «

"FUNCTIONS OF THE SALES EXECUTIVE"—Such constantly changing factors as markets, competition and buyers' needs, call for continuous study of the sales management function according to "Functions of the Sales Executive" a report recently issued

Sil-Fos

THE LOW TEMPERATURE BRAZING ALLOY FOR NON-FERROUS METALS

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For over two years, SIL-FOS has been making gas-tight joints—thousands of them—for SERVEL, INC. in condensers used in their industrial refrigerating units. Following is taken from a letter which tells the story.

I might mention that the soldering operation on the heads of these condensers is a very critical operation. 32 hard copper tubes protrude through a comparatively light copper tube sheet and the joint at this point separates the water circuit and the refrigerant circuit at a differential of approximately 150 lbs. per square inch. Leaks naturally cannot be tolerated in this point and when we started experimenting with this type of condenser, the proper bonding at this point seemed almost unsurmountable.

The complexity of the problem will be appreciated when it is understood that each of our 20 ton machine units contains 6 sections of shell and tube condensers, each section having 31 tubes. When Sil-Fosing at both ends, we therefore must get a gas-tight bond on 372 joints in each machine. We are glad to say that we have been entirely successful in using Sil-Fos for this purpose and though this type of construction has been used on some eight or ten of our regular models for over two years, we have yet to receive the first complaint from leakage at these points. We have likewise seen no evidence of electrolytic or corrosive action on the joints and from our laboratory experience, do not anticipate any trouble of this nature.

IF gas-tight joints between non-ferrous metals are important to you, SIL-FOS Brazing Alloy will produce them—and do it economically. Bulletin 510W explains how and why SIL-FOS, with its low working temperature and exceptionally free-flowing quality, assures strong, sound, ductile joints at low cost per joint. Write us for a copy—today.

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by the Metropolitan Life Insurance Co. The report is based upon a survey made by the Metropolitan's Policyholders Service Bureau of the practices and experiences of 120 manufacturing concerns. Many important trends in the field of sales management were brought out in the course of this investigation. Some of the more significant of these are:

1. More careful and scientific sales planning.
2. Greater centralization of authority over basic sales policies.
3. Increasing decentralization of responsibility for execution of the sales program.
4. Sharper division between responsibilities for planning and executing the sales program.
5. Increasing application of the principle of specialization to sales work.
6. Growing influence of the sales executive in the councils of the company.

The scope of the sales management function is discussed under four general divisions as including those relating to (a) the sales program, (b) the product, (c) the market and other "outside" factors, and (d) the sales organization. One section of the report discusses the duties of sales executives under various types of organization set-ups, and is illustrated by case studies. Another analyzes the way in which the sales manager spends his time. Others deal with the assignment and delegation of functions within the sales department, the nature and amount of field work done by sales executives, and the coordination of sales with other phases of the business.

Interested executives may obtain copies of "Functions of the Sales Executive" from the Policyholders Service Bureau, Metropolitan Life Insurance Company, 1 Madison Ave., New York City.

Trade Literature

WELD-O-TROL WELDING CONTACTOR—A 4-page illustrated booklet published by Westinghouse Electric & Mfg. Co. announces a new Weld-O-Trol electronic power switch for controlling the primary of welding transformers and suitable for use with existing timing devices and for welding mild steel products and other readily welded metals. As an approximation, the WL-652 and WL-657 tubes give a rating for spot welding approximating that of a 300-amp. contactor, while the WL-651 and WL-656 tubes roughly approximate the rating of a 600 amp. contactor. The rating of the continuously pumped Weld-O-Trol is such that it will handle applications previously almost impossible because of difficulty of switching the welding machine current.

Copies of this booklet, Descriptive Data 18-345, may be secured from the nearest district office of Westinghouse, or from headquarters at East Pittsburgh, Pa.

» «

MODEL SFA ENGINE-DRIVEN WELDER—An 200-amp. capacity engine-driven welder, especially designed for rural and field service where power supply is not available, is described in a leaflet published by Westinghouse Electric & Mfg. Co. Its compact construction permits hauling on practically any type of truck body. Copies of this leaflet, Descriptive Data 26-140, may be secured from the nearest district office of Westinghouse or from headquarters at East Pittsburgh, Pa.

» «

PREVENTING ADHESION OF WELD SPATTER—Wayne Chemical Products Co., Copeland and M.C. R.R., Detroit, Mich., has issued a bulletin describing its No. 2 metal coating. This new product is a water soluble compound for application in flash welding to keep the jaws of welding machines from loading with spatter.

The usual method of scraping this spatter which accumulates on the jaws is overcome by spraying the jaws with this preparation which quickly forms a tough coating to which the spatter will not bond. The length of time which "one spraying" is effective depends on both the thoroughness of application and type of work. As the coating, when dry, is more effective, it is advisable

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Blue Flux Coated

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whenever possible to allow time for drying or to speed drying with air hose or other simple means.

Aside from preventing adhesion of spatter, No. 2 metal coating acts as a flux and gives a more uniform weld on all automatic ring welding operations. The welded seam is more uniform and there is less tendency for the rod to short out—requiring repairs by hand. Better results are obtained by letting the metal coating dry before welding. If sprayed, only 5 to 10 min. is required for drying.

» «

THE HARNISCHFEGER CORP., Milwaukee, Wis., announces the appointment of the PLATTNER WELDING SUPPLY CO., 210 East Tenth St., Coffeyville, Kan., as exclusive agent for P&H-Hansen arc welders and Smootharc welding electrodes. The Plattner Welding Supply Co. will operate under the supervision of the Kansas City office of Harnischfeger Corp.

» «

THE THOMPSON-GIBB ELECTRIC CO. of Lynn, Mass., has announced that WILLIAM H. GIBB of the Thomson-Gibb Co. has established offices at 101 North 33rd St., Philadelphia from which he will serve the Philadelphia territory which includes eastern Pennsylvania, southern New Jersey, Delaware, Maryland and Virginia. Mr. Gibb has had many years of experience in the field of resistance welding, having founded and served as president of the Gibb Welding Machines Co. of Bay City, Mich., until it was merged with the Thomson Co. in 1929 to form the Thomson-Gibb Electric Welding Co.

» «

NEW MUREX DISTRIBUTORS—V. B. ANDERSON Co., Los Angeles, Calif.; CHICAGO TUBE & IRON Co., Chicago, Ill.; FARQUHAR MACHINERY Co., Jacksonville, Fla.; FULTON SUPPLY Co., Atlanta, Ga.; GRAMMER, DEMPSEY & HUDSON, Newark, N. J.; GRAND RAPIDS SUPPLY Co., Grand Rapids, Mich.; ALBERT W. ROTH, Kansas City, Mo.; STANDARD SUPPLY & HARDWARE Co., New Orleans, La., and WELDERS SUPPLY Co., Houston, Texas, have recently been appointed distributors of Murex heavy coated electrodes by METAL & THERMIT CORP., New York, N. Y.

All of these supply houses will stock the complete Murex line, including mild steel electrodes for downhand, for fillet welding and for vertical and overhead; low-alloy electrodes for welding a number of such steels as carbon-molybdenum and Cor-Ten; stainless and manganese steel electrodes and hard-surfacing electrodes.

» «

THE SULLIVAN MACHINERY Co., Michigan City, Ind., has released an attractive 20-page catalog (Bulletin A-22) describing and illustrating their Unitair stationary and semi-portable air compressors. A number of refinements and improvements have been made to this popular line of compact, two-stage, air-cooled compressors including the addition of a larger size (435 cu. ft. per min. displacement), the use of force feed lubrication and the design of a simplified automatic stop-and-start control for motor-driven styles. The new bulletin fully describes these improvements and also covers power unit driven types.

» «

WELDING TORCH BULLETIN—Victor Equipment Co., 844 Folsom St., San Francisco, Calif., has just issued an attractive 30-page booklet describing Victor's line of welding torches. The booklet was prepared with the thought of presenting a maximum amount of practical information for the man who is using oxy-acetylene welding torches. Many practical questions regarding Victor equipment are answered in easily understood terms. Various types of welding flames are described and illustrated. The interchangeability of Victor welding torches is illustrated with the help of numerous illustrations detailing interchangeable tips and holders. Maintenance suggestions, with several excellent photographs, shows clearly how Victor torches can be kept in first-class condition at all times.

» «

"TWIN ENGINED FOR PROGRESS" is the subject of an attractive booklet just issued by the recently formed Allegheny Ludlum Steel Corp., Brackenridge, Pa. The booklet traces the growth of the two companies, their present facilities, assets and products, and outlines developments leading up to the recent merger. How the new company plans to follow through in promoting a wider use of stainless steel is also explained.

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WELDER—Age 23, Single. Welding school graduate in electric, acetylene and cutting. Studious and ambitious. Willing to go anywhere. Anthony Theil, 151 W. Witt St., Philadelphia, Pa.

GAS AND ELECTRIC WELDER—12 yrs. experience. Boiler Welding. Age 38, Married. Want steady work. Willing to go anywhere. Address Box 16, Oak Grove, Oregon.

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ELECTRIC ARC AND ACETYLENE WELDING—Instructor in school, also several years exp. in shop work. Own equipment. Married. Willing go anywhere. Ernest Pearson, 1226-17th Ave., Rockford Ill.

GAS WELDER—25 yrs. exp. Also brazing and soldering. Martin Danko, 4412 Wilson Ave., Chicago, Ill.

WELDER—Want job in shop doing electric welding only. 4 yrs. welding experience and 1 yr. boat welding. Completed welding course. Age 23. Duane Schwandt, Willmar, Minn.

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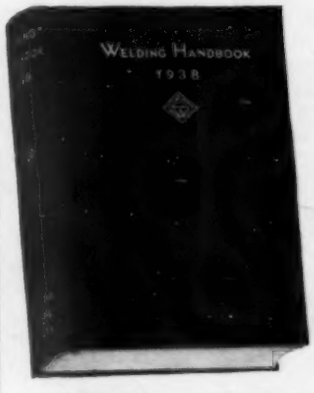

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